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A Summary of Current Program 7/1/66  
and Preliminary Report of Progress  
for 7/1/65 to 6/30/66

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MARKET QUALITY  
RESEARCH DIVISION  
of the  
AGRICULTURAL RESEARCH SERVICE  
UNITED STATES DEPARTMENT OF AGRICULTURE  
and related work of the  
STATE AGRICULTURAL EXPERIMENT STATIONS

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This progress report is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of USDA and cooperative research issued between July 1, 1965, and June 30, 1966. Current agricultural research findings are also published in the monthly USDA publication, Agricultural Research. This progress report was compiled in the Market Quality Research Division, Agricultural Research Service, U. S. Department of Agriculture.

UNITED STATES DEPARTMENT OF AGRICULTURE

Hyattsville, Maryland 20782

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## INTRODUCTION

Market Quality research deals with the measurement, improvement, and protection of the quality of agricultural commodities in marketing channels. The work encompasses physiological, biochemical, pathological, and entomological problems encountered during the storage, transport and distribution of agricultural commodities, and the development of new methods and devices for evaluation of quality.

The Market Quality Research Division is a part of the Agricultural Research Service. It is headquartered at Hyattsville, Maryland. The greatest concentration of its scientific personnel is at Beltsville, Maryland. Here the Instrumentation Research Laboratory, the Post-Harvest Physiology Pioneering Research Laboratory, personnel of the Field Crops and Animal Products Research Branch, and the Horticultural Crops Research Branch are located. Additional personnel are located in Washington, D. C. There are also 23 field stations located throughout the country; nine of these are located at State Universities or branch Experiment Stations, and two in terminal markets. Total research effort including research contracts amounts to approximately 135 scientist man-years.

Although a large variety of excellent quality fresh and processed agricultural products are retailed at reasonable prices throughout the year there is need for further research on methods to reduce spoilage and waste during storage, transportation and distribution and to improve methods for evaluation of quality. Stored product insects and market diseases still destroy large amounts of produce. Also there is urgent need for new methods of control that will not create health hazards due to pesticide residues. There is increasing need for automated objective methods of quality evaluation to make possible rapid reliable grading and inspection of large quantities of produce under modern packing and handling conditions.

As might be expected an appreciable amount of Market Quality research is related to the effective performance of the Service Divisions of the Consumer and Marketing Service responsible for standardization, inspection, and grading of agricultural commodities. The Division also works closely with industry and other Government Agencies on various problems relating to agricultural commodities in the marketing channels. Specific examples of Market Quality research accomplishments over the past five years are:

Improved Handling and Shipping Practices Developed for Cantaloups, Lettuce, and Red Tart Cherries. Cantaloups South Texas has an expanding cantaloup industry, due largely to development of a variety adapted to the area. However, marketing has been complicated by surface mold growth on the mature melons that adversely affects appearance and salability and sometimes causes decay. Research at the Harlingen, Texas laboratory has developed a hot water treatment (30 seconds at 135°F.) which cleans up the surface molds and dries the stem scar. During the present shipping season 7 heat treating units have been installed in commercial packing houses. In addition, 2 of the units operated successfully during the spring shipping season in Mexico.

Transportation of lettuce Laboratory studies at Fresno and Beltsville have shown that reduced oxygen in the range of 1 to 5 percent at simulated transit temperatures (33 to 40°F.), substantially reduces russet spotting in susceptible lots of head lettuce as compared with holding in air, during marketing. Shipping tests were conducted to determine low oxygen effects under transcontinental shipment in commercial rail car and van equipment. Comparisons in 8 paired-car and 15 paired-trailer tests included liquid nitrogen refrigeration vs. mechanical refrigeration and mechanical refrigeration supplemented with nitrogen vs. mechanical refrigeration alone. The tests indicated shortcomings in liquid nitrogen-refrigerated equipment which can probably be corrected. Lettuce shipped under reduced oxygen had less russet spotting but decay at market was related directly to average transit temperature rather than to oxygen concentration. Because of the availability of several types of commercial equipment and the intense industry interest, tests are being continued.

Red Tart Cherries Scald is a troublesome defect in processed red tart cherries. Susceptibility is related to bruise damage to fruit during harvesting and handling and it has increased with mechanized harvesting. Research at Beltsville has shown that oxygen deficiency in soak tanks caused typical scald symptoms to develop in bruised fruits. Aeration equipment was tested under controlled soak tank conditions at a commercial processing plant in Pennsylvania. Scald did not develop on bruised cherries held in water with an oxygen level of 8.6 ppm. This finding if commercially adopted would substantially reduce scald damage in commercial packs.

Insect Protection in Food Warehouses. A dichlorvos vapor treatment was moved along from developmental research into practical trial application in a food storage warehouse for a full summer season. A vapor generator developed in the research program was used to make the applications. The warehouse remained insect-free while a general infestation of saw-toothed grain beetles developed in a similar warehouse which received standard treatments with a synergized pyrethrum aerosol. Twelve different foods were analyzed for dichlorvos residues after twenty weeks of exposure. The highest residue was 0.4 ppm. in one of the products. Most of them contained less than 0.1 ppm. The use of the

dichlorvos vapor generator in wineries has also given excellent control of Drosophila flies. A petition is pending to establish a tolerance for this preventive treatment, urgently needed for protecting foods against insect infestation in storage warehouses.

Nontoxic Mothproofing Treatment. Significant progress has been made in selecting and developing quaternary ammonium compounds as mothproofing treatments. Some of the effective compounds are so safe they are used in baby creams, cosmetics, and shaving lotions. Present methods of application continue to protect wool against insect damage even after three drycleanings but ways are being sought to make the treatments more long lasting.

Screening Method for Determining Salmonella Negative Samples of Dried Egg. Salmonella bacteria in foods can cause serious food poisoning. Present methods of examination of dried whole egg for these pathogenic bacteria are time consuming and expensive. We have developed a screening which requires no expensive equipment and produces reactions which are readily observed. The method consists of determining hydrogen sulfide production and mannitol fermentation in conjunction with the lactose broth pre-enrichment for Salmonella. The test has proven highly accurate with pasteurized dried whole egg.

New Instrument for Rice Grading. A rice meter combining light reflectance and transmittance principles, has been developed to measure three of the important quality factors of milled rice: degree of parboiling, color or general appearance, and degree of milling. The instrument is also expected to be useful for continuous monitoring of degree of milling in rice plants.

## EXAMPLES OF RECENT ACCOMPLISHMENTS OF THE STATE AGRICULTURAL EXPERIMENT STATIONS

Protein chemists have a new tool to help unravel the many complex structures of agricultural products. A quantitative and convenient procedure was developed for accurately analyzing all the essential amino acids of proteins. Owing to its speed and sensitivity, gas chromatography offers advantages as a novel analytical method for testing substances which can be volatilized. At the University of Missouri, biochemists W. M. Lamkin and C. W. Gehrke demonstrated that the non-volatile amino acids can be converted to butyl esters with just the right degree of volatility by condensing with a trifluoroacetate reagent. Their studies compared the efficiency of a number of closely related reagents and procedures in order to establish the validity of this new method.

Definition of Carcass Merit in Lamb. As a result of research in W-61, Development of Selection Criteria for the Genetic Improvement of Carcass Merit in Sheep, a definition of carcass merit in lamb was developed which is in effect, a carcass standard for high merit. The standard includes fat thickness over the loin, loin eye area, percent retail cuts, dressing percent, and uniform distribution of fat cover with discrimination against excessive cover over certain cuts.

A rapid clean-up procedure for analyzing chlorinated insecticide residues in milk was developed by researchers at the Indiana Agricultural Experiment Station. Milk samples are blended in deactivated florisil with suitable solvents prior to running the extracted material over a 6" deactivated florisil column. Upon evaporating the solvents, the residue is taken up in hexane and the sample is ready for analysis by electron capture gas chromatography (ECGC). This procedure eliminates ECGC interfering substances, allows up to 50 samples per day per technician, and permits larger samples for improved sensitivity.

Improvement of Keeping Quality of Butteroil. Researchers at Rutgers University have improved the keeping quality of butteroil by a very slight hydrogenation. The hydrogenation takes place under low pressure, low catalyst concentration and at a temperature of 140°C. Organoleptic evaluation shows the hydrogenated samples to have much improved keeping quality. The improvement in keeping quality is obtained through only a little loss of unsaturation. The unsaturation may be restored conveniently by the process of winterization. Hydrogenation and winterization are processes presently used on edible fats.

As a step toward implementation of the recommendations for a National Program of Research for Agriculture made jointly by the Association of State Universities and Land Grant Colleges and the USDA, a section has been added to each of the Areas in this report. It comprises a list of the related publications of the State Agricultural Experiment Stations in addition to those heretofore reported covering the results of USDA and cooperative research. In future years, it is anticipated that information will be available to permit reporting of achievements resulting from State research in a format comparable to the present reporting of the USDA and cooperative research.

## AREA 1

## CITRUS AND SUBTROPICAL FRUIT - MARKET QUALITY

Problem. Research is needed to develop better objective indices for measurement of quality of citrus and other subtropical fruits. This would result in more meaningful grades and standards which could be better enforced. Instrumentation and automatic devices for quality sorting on a commercial basis might be possible. Decays and fruit soilage present serious problems in both domestic and export markets. Much research is needed to relate mechanical harvesting, handling practices, packaging, precooling and transit refrigeration to wastage, and to develop effective treatments for decay reduction. There is need for further research on controlled atmosphere storage for citrus and other subtropical fruits. Problems which are sometimes distinct and sometimes interrelated exist in each of the geographical areas. These often require biological research in the separate production areas for solution.

## USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving largely applied research performed by horticulturists, plant physiologists, plant pathologists, and food technologists. Research is conducted in the producing areas of California, Florida and Texas. Market studies are made in Belle Mead, New Jersey and Chicago. P. L. 480 grants are operative for studies in India on identification and mode of infection of fungi causing postharvest rots of tropical fruits; in Spain on detection of additives in citrus juices; in Germany on the antimicrobial action of biphenyl; in Israel on maturation and ripening of avocados; and in India on metabolic changes during ripening of mangos. A contract study on citrus fruit quality as related to mechanical harvesting will cover one more harvest season at the Citrus Experiment Station, Lake Alfred, Florida.

Total federal scientist man-years devoted to this area is 12.4. Of this 1.5 is devoted to objective measurement of quality; 1.4 to quality maintenance during handling; 2.5 to quality maintenance during storage; 2.0 to quality maintenance during transportation (with emphasis on export); 2.0 to post-harvest physiology; and 3.0 to postharvest disease control. P. L. 480 projects in this area involve \$29,732 equivalent over a 5-year period in India; \$56,163 equivalent over a 4-year period in Spain; \$77,138 equivalent over a 5-year period in West Germany; \$83,620 equivalent over a 5-year period in Israel; and \$45,344 equivalent for a second 5-year project in India.

Projects terminated during this period included respiration and rind breakdown in citrus fruits (MQ 2-79) and precooling and transporting Florida citrus fruits and vegetables (MQ 2-53).

## PROGRAM OF STATE EXPERIMENT STATIONS

A total of 7 scientist man-years is devoted to this area of research.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Non-Destructive Sorting of Citrus Fruits for Quality. Good color separations with the commercial light reflectance sorter were obtained on Temple oranges and limes. Tests using light transmittance for sorting Hamlin oranges according to degreening requirement show degreening time to be related to the initial chlorophyll level, supporting results of earlier work. Preliminary tests with the commercial light reflectance sorter showed similar results. Light transmittance chlorophyll readings for evaluation of internal quality of Hamlin and Valencia oranges and Marsh grapefruit gave average correlation figures of 0.3 to 0.4--too low to be of value in predicting quality.

Hamlin and Valencia oranges were measured with a new optics reflectance accessory to the spectrophotometer to determine the appropriate wavelengths to effect a separation based on surface color. For separating green, yellow-green to orange fruit, 760 nm as reference wavelength and 675 nm as measuring wavelength effectively separated this wide range in the fruit color. For separating yellow from orange fruit the best separation was obtained using 650 and 540 nm wavelengths. (MQ 3-77)

2. Aromatic Polynuclear Hydrocarbons in Citrus Fruits. A method was developed for the cleanup and screening of citrus extracts for residues of three hazardous polynuclear hydrocarbons. Over fifty paired samples of washed (non-waxed) and commercially waxed citrus fruit were screened for residues. No traces of the polynuclear hydrocarbons were detected. (MQ 3-46)

3. Seasonal Changes in Florida Persian Limes. Florida Persian limes picked 160 days after September bloom were larger in diameter but lower in total soluble solids and citric acid content than those picked at a similar interval from the February bloom; no difference was found in juice content of fruit from the September and February blooms. (MQ 3-53)

4. The Detection of Additives in Citrus Juices. Under this P. L. 480 project in Spain detailed analyses have been made of common additives such as sugars and citric acid. Trace components of the commercial materials are important chemical clues to their use as additives. Substantial data have been developed on the mineral constituents of pure orange juice and additional research on synthetic carotenoids shows that the method developed for their detection is effective. (E25-AMS-6k)

## B. Quality maintenance in handling and packaging

1. Citrus Fruit Quality as Related to Mechanical Harvesting. A continuation of this contract research at the Florida Experiment Station through another harvest season largely confirms previous results. Both shaker and air blast methods of removal result in considerable fruit damage with an increase in postharvest decay. The results indicate possibilities for harvesting Hamlin oranges and Marsh grapefruit for the cannery but possibilities of harvest for fresh market appear remote. The only chemical under test that caused abscission injured the fruit and increased postharvest decay when the fruit was mechanically harvested. (MQ 2-65)

## C. Quality maintenance in storage

1. Controlled Atmosphere Storage of Florida Citrus Fruits. Controlled atmospheres with numerous levels and combinations of carbon dioxide and oxygen showed no advantage over air for Temple oranges and tangelos stored at 33° F. Condition and flavor were good after 4 weeks in both CA and conventional storage. After 10 weeks, severe decay and chilling injury occurred in all lots. The flavor of Marsh grapefruit was retained in both CA and conventional storage at 50°. The smallest amount of decay developed in the 2.5% O<sub>2</sub>-5% CO<sub>2</sub> atmosphere, but the most rind pitting developed in the atmospheres with 2.5% and 5% oxygen. Grapefruit waxed before storage developed more pitting than unwaxed fruit. (MQ 2-110)

2. Controlled Atmosphere Storage of California Oranges. Controlled atmosphere storage was evaluated for Valencia oranges during 4 months at 36° and 42° F. and Navel oranges during 4 months at 42°. Valencia oranges from CA were less acceptable than air-control fruit. Oranges from 1% oxygen were off-color and inedible. All Navel oranges except fruit from the 5% oxygen (flowing) and air-control treatments were inedible. Fruit from all static treatments showed some degree of off-flavor. (MQ 2-98)

3. Controlled Atmosphere Storage of Texas Grapefruit. Progressive infections of penicillium green mold, starting the seventh week, forced the termination of CA storage of Texas red grapefruit after 12 weeks. Rain which occurred on 20 of 27 days during December undoubtedly affected the keeping quality of this fruit which was harvested on December 27. Low CO<sub>2</sub> in storage atmospheres increased peel pitting which in turn provided entry points for green mold infections. Those lots stored with 2.5 to 10% O<sub>2</sub> and 2.5% CO<sub>2</sub> were in best condition after 12 weeks' storage. (MQ 2-98)

4. Controlled Atmosphere Storage of Florida Avocados, Mangos and Limes. At Miami after 30, 45 and 60 days in CA storage at 40° F., Lula avocados retained higher quality than comparable fruit stored in air. The most satisfactory atmospheres were 1% O<sub>2</sub>-10% CO<sub>2</sub> and 3% O<sub>2</sub>-15% CO<sub>2</sub>. After 60 days' storage, most of the fruits showed darkening of the skin, although the flavor of the flesh was rated good. The best storage environment for Keitt mangos for 20

days was 55° in 5% O<sub>2</sub>-5% CO<sub>2</sub>. Diplodia stem-end decay limited the storage period. After 30 days in CA storage at 50° in 1% O<sub>2</sub>-0% CO<sub>2</sub>, unwaxed Persian limes developed less scald on the peel than the waxed limes. (MQ 2-110)

#### D. Quality maintenance during transportation

1. Thermal Conductivity in Florida Citrus Fruit. No appreciable differences were found in the thermal diffusivity of Marsh grapefruit during five different stages of ripeness. The coefficient of variation of 5.22 percent indicated the validity of the experimental procedure and suggests reliability in the experimental results. No significant correlations were found between the thermal properties of conductivity and diffusivity and the physical properties of rind thickness, moisture content, or size of grapefruit. (MQ 2-53)

2. Export Shipments of Florida Grapefruit. During April 1966, three export shipments of grapefruit were made from Wabasso, Florida, to LeHavre, France, primarily to compare shipping containers. In the first two test shipments, fruit in fiberboard cartons developed less decay than fruit in wirebound containers. No difference in total decay was observed in the third test. The fiberboard cartons shifted less on the pallets than the wirebound containers. The wirebound container is more flexible than the fiberboard carton, resulting in the frequent appearance of "jumble pack" of grapefruit and probably accounting for greater physical damage. Some of the commercial shipments showed soft and overripe grapefruit on arrival. The findings again emphasized the need of better fruit selection for export grapefruit. (MQ 2-74)

#### E. Postharvest physiology

1. Maturation and Ripening of Avocados. A first progress report on this P. L. 480 project in Israel indicates initiation of studies on growth-inhibiting and growth-promoting substances in avocado flesh. Identification of these materials is being attempted. Various known growth substances are being applied to avocado fruits and a device for quantitative measurement of flesh softening has been developed. (A10-MQ-2)

#### F. Postharvest disease control

1. Control of Decay of Florida Citrus Fruit. 2-(4-thiazolyl) benzimidazole (Thiabendazole), a new fungicide, was more effective in laboratory tests than sodium orthophenylphenate (SOPP) and 2-aminobutane in controlling decay of mid- and late-season oranges. In five controlled tests in commercial packing houses, 2-aminobutane was better than SOPP for reducing decay in citrus fruits.

Decay of Robinson tangerines was directly related to period of ethylene treatment (degreening). Excessive stem-end rot and anthracnose decay developed in fruit degreened for 45 hours or more. Fungicides tried were ineffective.

Postharvest Phomopsis side rot developed following grove inoculations made 4 months before harvest. (MQ 2-65)

2. Materials Affecting Germination and Growth of Decay Organisms. Germination of Diplodia natalensis spores in extracts of orange flavedo or albedo occurred over a pH range of 2.5 to 8. In .1 and .05 m. citrate buffer, germination was limited between pH 3-5 with a maximum at pH 4. Triton X-100, a wetting agent, did not inhibit germination, but when present with .05 m. buffer, germination was reduced and germ tubes were abnormal. (MQ 2-100)

3. Postharvest Diseases of Tropical Fruits. The survey of occurrence and identification of organisms causing postharvest decay in 6 tropical fruits is continuing under P. L. 480 grant in India. Post infection changes in sugar content of some fruits were studied by chromatographic analysis. Maximum, minimum and optimum temperatures and pH values for growth and sporulation of 3 common decay organisms were determined. Thirteen fungicides were tested for postharvest application. Of these, 6 were ineffective, others were effective against a few decay organisms and 3 chemicals checked the growth of all organisms. (A7-AMS-6)

4. Antimicrobial Action of Biphenyl. The literature review, which was the first phase of this P. L. 480 project in Germany, is completed and soon to be published. Research is underway on the influence of biphenyl and sodium orthophenylphenate on carbohydrate metabolism of Penicillium italicum and Trichoderma lignorum, both of which cause decay in citrus fruits. Inhibitory effects of biphenyl and SOPP were also related to pH of the growth medium. (E10-AMS-3)

5. Proteolytic Enzymes and Inhibitors in Decay Producing Fungi. Ten previously unreported host-pathogen combinations exhibiting protease action were discovered. Casein was found to be a better substrate, in most cases, for protease assay than either hemoglobin or alpha protein from soybean. It is now clear that proteases are produced during plant disease progression in a substantial number of cases. Some of these, for example Phomopsis stem end rot of orange, are important diseases on high-value crops. (MQ 2-97)

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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- Hatton, T. T. and W. F. Reeder. 1965. Maturity of minor varieties of Florida avocados, 1964-65. Proc. Fla. State Hort. Soc. 78:327-330. (MQ 3)
- Jahn, O. L. and M. B. Sunday. 1965. Color changes in citrus fruit as measured by light transmittance techniques. Proc. Fla. State Hort. Soc. 78:229-232. (MQ 3-77)
- Primo, E., J. Sanchez and J. Alberola. 1965. Deteccion de adulteraciones en zumos citricos. III. Identificacion de acidos no volatiles en zumos de naranja de procedencia americana. Agroquímica y Tecnología de Alimentos, 5(1):121-124. (E25-AMS-6k)
- Primo, E., J. Sanchez Parareda and J. Alberola. 1965. Deteccion de adulteraciones en zumos citricos. IV. Los acidos no volatiles y aminoacidos que impurifican al acido citrico de fermentacion. Agroquímica y Tecnología de Alimentos 5(2):211-215. (E25-AMS-6k)
- Primo, E. and J. Royo Iranzo. 1965. Deteccion de adulteraciones en zumos citricos. V. Composicion mineral de los zumos naturales de naranja industrializados en Espana. Agroquímica y Tecnología de Alimentos 5(2):216-224. (E25-AMS-6k)

Quality Maintenance During Storage

- Harding, P. L., G. L. Rygg, Wm. G. Chace and J. J. Smoot. 1966. Citrus fruits. ASHRAE Guide and Data Book--Applications Volume for 1966 and 1967, pp. 659-664. (MQ 2)
- Hatton, T. T., Jr., and W. F. Reeder. 1965. Controlled atmosphere storage of Lula avocados--1965 tests. The Citrus Industry 40(10):29-31. (MQ 2-110)
- Hatton, T. T., Jr., Wm. F. Reeder, and C. W. Campbell. 1965. Ripening and storage of Florida Avocados. USDA, MRR 697. (MQ 2-46)
- Hatton, T. T., Jr., Wm. F. Reeder and C. W. Campbell. 1965. Ripening and storage of Florida mangos. USDA, MRR 725. (MQ 2-46)

Quality Maintenance During Transportation

- Atrops, E. P. 1965. Improved load pattern reduces citrus decay in ship vans. Calif. Citrog. 50(11):441-444. (MQ 2-27)

Chace, Wm. G., Jr., Paul L. Harding, John J. Smoot and Randall H. Cubbedge. 1966. Factors affecting the quality of grapefruit exported from Florida. USDA, MRR 739. (MQ 2-74)

### Postharvest Disease Control

Davis, P. L. and J. J. Smoot. 1965. Inducement of germination of *Penicillium digitatum* spores by orange rind components and effect of pH on substrate. *Phytopathology* 55:1216-1218. (MQ 2-65)

Houck, L. G. 1965. *Penicillium* development in lemons treated with 2,6-dichloro-4-nitroaniline. *Plant Disease Reporter* 49:715-719. (MQ 2-24)

Norman, Shirley, G. L. Rygg and A. W. Wells. 1966. Improved cleanup method for determination of biphenyl in citrus fruits and in biphenyl impregnated kraft papers by thin-layer chromatography. *J. Assoc. Official Anal. Chem.* 49:590-595. (MQ 2-28)

Smoot, John J. and C. F. Melvin. 1965. Grove inoculation studies with stem-end rot fungi. *Phytopathology* 55:1077. (MQ 2-65)

Ghosh, A. K., R. N. Tandon, S. N. Bhargava and M. P. Srivastava. 1965. Vitamin C content of Guava fruits after fungal infection. *Die Naturwissenschaften*, Heft 16, S. 478, 52. Jahrgang. (A7-AMS-6)

Ghosh, A. K., R. N. Tandon, S. N. Bhargava and M. P. Srivastava. 1965. Formation of a new oligosaccharide in mango fruits under pathogenesis. *Curr. Sci.* 34(15):465. (A7-AMS-6)

Ghosh, A. K., R. N. Tandon, S. N. Bhargava and M. P. Srivastava. 1965. Utilization of oligosaccharides by some anthracnose fungi. *Proc. of the National Academy of Sciences, India. Sect. B., Vol. XXXV, Part II*, pp. 197-202. (A7-AMS-6)

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Objective Measurement of Quality

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Quality Maintenance in Storage

Eaks, Irving L. and Estuardo Masias. 1965. Chemical and physical changes in lime fruits during and after storage. J. Food Sci. 30(3):509-515. (Calif.)

Khalifah, R. A. and J. R. Kuyendall. 1965. Effect of maturity, storage temperature and prestorage treatment on storage quality of Valencia oranges. Proc. Amer. Soc. Hort. Sci. 86:288-296. (Ariz.)

Oberbacher, M. F. and L. C. Knorr. 1965. Increase of rumple and decay in lemon fruits during storage. Proc. Amer. Soc. Hort. Sci. 86:260-266. (Fla.)

## AREA 2

## DAIRY PRODUCTS - MARKET QUALITY

Problem. Dairy products in marketing channels are subject to deterioration by microbiological action and by oxidative processes. In addition, several kinds of insects and mites may contaminate or damage dairy products during storage and distribution. Improved tests for estimating initial quality and information on factors influencing keeping quality would be useful to minimize deterioration in marketing channels. There is also a need for simple, accurate tests for estimating fat, solids-not-fat, and protein in all types of dairy products in order to maintain accurate control of composition and to permit realistic pricing of milk. Pasteurized milk invariably spoils within a week or two from bacterial growth in refrigerated storage. Information is required on the source of the spoilage organisms and on how they may be eliminated. Safe and effective methods of preventing or controlling insect and mite infestations are needed. More information is needed on the storage-life of butter and butteroil under various conditions and on the factors which predispose these products to deterioration. Contamination by pesticides residues continues to be a major problem. Simplified methods are needed of detecting such residues in dairy products and also in feeds so that excessively contaminated products may be removed from marketing channels.

Modern marketing practices in the dairy industry have intensified the problems of detecting inferior lots of milk and of increasing the storage-life of dairy products. Several kinds of insects and mites contaminate or damage dairy products during processing, storage, and distribution. To maintain quality of these products in marketing channels, research is needed on the factors influencing keeping quality; on developing new and improved objective quality tests for bulk milk and other products; on developing safe and effective procedures for preventing or controlling insect and mite infestations; and to find improved and simplified detection methods for antibiotic and pesticide residues in dairy products.

## USDA AND COOPERATIVE PROGRAM

There is a continuing program of basic and applied research aimed at developing new and improved methods for assessing the important quality factors in a variety of dairy products. At Beltsville, Maryland, studies of the shelf-life of canned butteroil and ghee, prepared from cold storage butter, has been completed. (MQ 3-49) Work on chlorinated pesticide residues in dairy products has been expanded to cover feeds and forages. A detailed study of procedures for direct microscopic counting of bacteria in milk has been completed. (MQ 3-76) Work on moisture distribution in butter is continuing. The Federal scientific effort devoted to research in this program totals 1.0 scientific man-years.

A program headquartered at Fresno, California, involved basic and applied entomological research directed toward the prevention of insect and mite infestation in dairy products in the marketing channels. The Federal effort on this program during the reporting period was 1.0 scientist man-year, of which 0.6 man-year was in contract research. The entomologist was at the University of Wisconsin doing graduate work under the Division's training program. Much of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the problems in dairy products.

A 2-year contract with the Stanford Research Institute is for a study to identify and synthesize the natural attractants in certain dermestid beetles.

A grant to the Tokyo University of Agriculture, Tokyo, Japan, is for a 3-year study part of which is on the constituents of dairy products that attract mites. It continues until August 1968, and involves PL 480 funds with a \$38,622 equivalent in Japanese yen.

Line Project MQ 1-6 on mite fumigation studies was terminated in February 1966.

#### PROGRAMS OF STATE EXPERIMENT STATIONS

A total of 16 scientist man-years is devoted to this area of research.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Objective Measurement of Quality

1. Stability of Anhydrous Butterfat. All samples opened after two years' storage at 32°, 70°, and 100°F. exhibited obvious deterioration. (MQ 3-49)
2. Moisture Distribution in Butter. A commercial conductance meter with special electrodes proved satisfactory for measuring electrical conductance in butter. Polarization effects were eliminated by dipping the electrodes in a dilute salt solution between readings. No clear correlation has been found between electrical conductance and keeping quality; however, samples of high conductance were visibly "leaky." (MQ 3-57)
3. Pesticide Residues. An improved technique for thin layer chromatography was developed which incorporated silver nitrate in the plate as a chromogenic agent plus a small amount of oxidized fat to suppress interference from fat in the samples. The method will easily detect 0.01µg of

most common chlorinated insecticides. Studies of the analyses of various types of livestock feeds using thin layer chromatography were begun, using a one-gram sample of dry feed. Four samples require about 2½ hours for analysis. (MQ 3-70)

4. Direct Microscopic Counts. Work was completed on a study of the correlation between standard plate count (SPC) and four direct microscopic counting (DMC) procedures. The DMC stains used were (A) the Levowitz-Weber methylene blue stain, (B) a modification of (A) incorporating basic fuchsin, (C) alcohol-acetic acid fixation followed by a periodic acid-bisulfite-toluidine blue stain, and (C) alcohol-acetic acid fixation followed by stain with toluidine blue buffered to pH 4.0. Correlations between DMC and SPC were greatly affected by the type of bacteria and the staining procedure used but were not affected by such factors as the number of fields counted for DMC, the position on the DMC smear, or by using various definitions of clumps (touching, within 1 cell diameter, within 2 cell diameter) for the DMC. Using stain A for example, the correlation between DMC and SPC ranged from 0.930 for Pseudomonas fluorescens to 0.146 for Bacillus subtilus. For all bacteria, correlations between SPC and DMC were: Stain A, 0.858; Stain B, 0.429; Stain C, 0.685, and Stain D, 0.917. The precision of the DMC varied directly with the number of cells in the sample but varied inversely with the square root of the number of fields counted. The precision of counting was not affected by the staining procedure used. (MQ 3-76)

## B. Prevention of Insect Infestation

1. Biological and Physical Control. About 30,000 female black carpet beetles are reared each month for collection of sex attractant either by aeration or by maceration in benzene. The active components can be manipulated by high-vacuum short-path distillation, column chromatography, thin layer chromatography and chemical treatment but not by gas chromatography. The threshold of response of the males generally occurs at a concentration of 1/10,000 female equivalent. The preliminary work conducted indicates that full-scale attempts to isolate and identify the active compounds can now be undertaken. A manuscript on the collection of the pheromones with absorption columns has been accepted for publication in the Journal of Economic Entomology. (MQ 1-32(C))

There was no difference in the luring activity of five varieties of cheese to the cheese mite. Studies, therefore, are under way to isolate the volatile attractive compounds from Cheddar cheese. (All-MQ-3(a))

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## AREA 3

## DECIDUOUS FRUIT AND TREE NUTS - MARKET QUALITY

Problem. Deciduous fruits and tree nuts are subject to deterioration after harvest through normal metabolic processes and from decay organisms. In addition these products vary widely at harvest in the characters that determine market acceptance. Practical objective measurements of quality would greatly assist in standardization and grading procedures, and the development of instrumentation for this purpose increases the chance for automatic quality sorting on a commercial basis. Additional information on physical and chemical methods for decay reduction and on product quality as related to mechanical harvesting would be useful. Research is needed on storage environment as related to temperature, air movement, humidity, atmosphere modifications and fumigants. Research must be continued with transportation equipment and services as affecting ultimate quality of the product in the market. Dried fruits and tree nuts are subject to insect infestation while drying in the field, during storage while they await processing, in the processing plant, and in marketing channels until they reach the final consumer. Research is necessary to develop more effective measures for preventing insect infestation all along this line. Emphasis must be given to finding methods that will avoid both insect contamination and pesticide residues.

## USDA AND COOPERATIVE PROGRAM

The Department has a long-term program of basic and applied research involving horticulturists, plant physiologists, plant pathologists, and food technologists. The research includes definition, measurement, and maintenance of quality during the period between harvest and consumption. Locations include Beltsville, Md.; Wenatchee, Wash.; Fresno, Calif.; Raleigh, N. C.; Chicago, Ill.; and Belle Mead, N. J. Cooperative agreements and limited contributed funds are in effect with the California Strawberry Advisory Board. P.L. 480 supported research is underway in Finland on the effects of pesticide sprays on the storage life of certain fruits and in Italy on the principal rots of apples and pears.

A continuing program headquartered at Fresno, California, involves basic and applied research directed toward the prevention of insect infestation in dried fruits and tree nuts. The work is conducted in cooperation with California State and County agencies and several industry groups. Some of the latter provide limited funds through the Dried Fruit Association of California in support of the program. Much of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the problems in dried fruits and tree nuts.

Federal effort in this program totals 19.4 scientist man-years divided as follows: Objective measurement of quality 2.7; quality maintenance in handling and packaging 2.8; quality maintenance in storage 2.7; quality maintenance during transportation 1.0; postharvest physiology 2.5; postharvest disease control 4.5; and prevention of insect infestation 3.2. Research under P.L. 480 includes a 3-year study in Italy for \$18,357 equivalent; a 5-year project in Finland for \$96,441 equivalent, involving the effects of pesticides on storage life and composition of fruits; and a 5-year study in Poland for \$34,966 equivalent, on the ecology of mites attacking dried fruits and herbs.

Projects terminated during this period included: Control of pear scald (MQ 2-66), lenticel spot of Golden Delicious apples (MQ 2-72), gamma radiation on market life (MQ 2-82), quality measurement of apples (MQ 3-28), quality measurement of red tart cherries (MQ 3-27) and the P.L. 480 projects rots of apples and pears (E15-AMS-2a) and apple respiration in modified atmospheres (E29-AMS-1a).

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 17 scientist man-years is devoted to this area of research.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Objective measurement of quality

1. Eastern Apples. Full spectral transmittance curves were obtained on intact Delicious apples (single and double red strains) grown in Maryland, and Starking Delicious grown in Washington State. Numerous wavelengths were correlated with destructive tests on individual fruit.  $\Delta OD(600-640)nm$  correlated highest with soluble solids and Brix/acid ratio. (MQ 3-28)

2. Western Apples. Starking Delicious apples soften and have a progressive loss of chlorophyll with an increase in the number of days from bloom. Firmness and soluble solids are inversely correlated while titratable acidity and chlorophyll are directly correlated at each harvest date.

Golden Delicious follow the same trend as Starking Delicious except that Goldens soften more rapidly during the early storage period. Examinations after 3, 5, and 7 months' storage confirm that firmness, soluble solids, titratable acidity, and dessert quality of Golden Delicious are inversely related to the instrument measurement of internal chlorophyll at harvest time.

Alar (dimethylamino-succinamic acid) treated (preharvest) Golden Delicious were slightly preferred by a taste panel. Treated Golden and Starking Delicious were a little firmer than the controls after 7 months' storage. The treated Starking Delicious were less stale but more grainy in texture than the control fruit at the end of the storage season. (MQ 3-28)

3. Red Tart Cherries. Scald develops in bruised cherries in soak tanks with low oxygen concentration in the water. A tank aeration system was tested under controlled commercial conditions. A commercial aeration system proved an effective means of increasing oxygen level of water, thus controlling

cherry scald. Laboratory experiments with bruised cherries in water or in an  $N_2$  atmosphere showed that 2 ppm of oxygen is the critical level below which scald develops.

Callose formation in bruised red tart cherries was demonstrated by means of aniline blue fluorescence method. Formation of callose is apparently related to the phenomenon known as firming which occurs when cherries are bruised and aged. (MQ 3-27)

4. Blueberries. Optical density differences between selected pairs of wavelengths in region 400-800 nm were explored for possible relationship with anthocyanin pigment content of individual blueberries. The highest correlation, 0.915, was found between  $\Delta OD(700-800)nm$  and milligrams anthocyanin per berry. (Exploratory)

#### B. Quality maintenance in handling and packaging

1. Film Permeability for Apple Box Liners. Minimum and maximum carbon dioxide accumulations, calculated as arithmetic means on 27 lots of 5 test liners, containing 3 varieties of apples, during 180 days' storage were 4.1 and 6.6 percent, respectively. The oxygen atmospheres were 6.2 and 10.9. Final atmospheres were 4.4 percent carbon dioxide and 10.4 percent oxygen. A simple formula was developed to calculate a better index of liner performance than is possible with either a final or arithmetic-mean atmosphere.

Analyses of 122 measurements of 5 film types showed that the ratio of carbon dioxide to oxygen increased 47 percent as temperatures decreased from 68° F. to 32° F.

Mechanically measured permeabilities of test films were compared with biological estimates computed by the RSAV method. When known variables were controlled, the results obtained by the two methods differed from each other over a range of 1.3 to 6.2 percent. The basic concepts of the RSAV formula were further confirmed. (MQ 2-63)

2. Blueberries. A survey of some 250 Highbush varieties and seedlings showed that acid content of fruit at the last identifiable stage of ripeness (purple at stem scar) varies from .5 to nearly 3.0 percent and soluble solids content from 6 to nearly 12 percent. Composition was to some extent correlated with the development of decay in such fruit. (MQ 2-94)

#### C. Quality maintenance in storage

1. Controlled Atmosphere Effects on Apples. Jonathan, Delicious, Golden Delicious, Rome and Stayman apples stored 4 and 6 months at 32° F. in 1%  $O_2$  (zero  $CO_2$ ) followed by 7 days at 70° in air were free of scald, Jonathan spoiling and internal core or flesh browning. McIntosh apples stored at 3 in 1%  $O_2$  had some skin and flesh browning similar to that found on fruit from zero  $O_2$  atmospheres, indicating that 1%  $O_2$  is insufficient for McIntosh.

McIntosh, Delicious, Rome and Stayman apples stored in air or polyethylene-lined boxes were moderately to severely scalded; Jonathans had severe Jonathan spot; and Golden Delicious stored in air were badly shriveled. Fruits stored in zero  $O_2$  atmospheres developed variable amounts of skin and flesh browning and were off flavor. Carbon dioxide production in air after storage was lowest and acidity and firmness highest in fruit from the 1%  $O_2$  atmospheres. (MQ 2-63)

2. Controlled Atmosphere Storage of Eastern Peaches and Nectarines. Firm ripe peaches stored 6 to 9 weeks in air at 32° F. failed to reach satisfactory eating ripeness when transferred to 65°. Those stored in 5%  $CO_2$  and 21%  $O_2$  were somewhat better than those from air. Those from the best atmospheres (1/4, 1 or 3%  $O_2$  with 5%  $CO_2$ ) were of borderline acceptability when ripened after 6 to 9 weeks of storage. Peaches stored in low-oxygen atmospheres with  $CO_2$  respired more slowly during ripening and were softer, more acid, and had better flavor than those stored without  $CO_2$ . Late Le Grand nectarines stored in air at 32° F. failed to ripen satisfactorily after only 3 weeks' storage. Otherwise results with nectarines were similar to those obtained for peaches. (MQ 2-99)

3. Storage Life of Apples as Related to Rate of Cooling. Hydrocooled apples and those cooled in 3 and 7 days were of comparable quality at all examinations after storage. Apples cooled in 14 and 28 days were decidedly inferior to those cooled more rapidly as judged by flesh firmness and taste. Total solids and acids were about equal in all lots. The differences in dessert quality due to the different cooling rates became less pronounced with advancement of the storage season. A high percentage of the slowly cooled (14 and 28 days) Golden Delicious apples decayed during storage. Little decay occurred in Red Delicious fruit from any of the cooling rates. (MQ 2-127)

#### D. Quality maintenance during transportation

1. Air Shipment of California Strawberries. Domestic shipments--Summer shipments of California strawberries in jet cargo aircraft to eastern markets required an average of 17.8 hours from shipping point to wholesaler. Only 33 percent of the time was spent in the air, 21 percent on trucks, and 45 percent at airports. Ambient temperatures averaged 67° F.; precooled strawberries averaged 50°; and non-cooled berries averaged 65° during transit. Precooled fruit shipped on an open pallet averaged 54°, that on a pallet covered with a fiberboard sleeve averaged 51°, and that with a sleeve plus polyethylene liner, 45°. Differences in temperature due to type of pallet cover were smaller in non-cooled fruit, averaging 62° to 68°. Dry ice was effective in building up  $CO_2$  atmospheres only when used with a polyethylene liner. Decay losses were smallest in precooled fruit, shipped with dry ice, on pallets covered with a polyethylene liner and a fiberboard sleeve. When fruit temperatures were kept below 40° F., the modified atmosphere produced by the dry ice was not needed. When temperatures were higher, the  $CO_2$  given off by the dry ice partially compensated for the lack of refrigeration.

Spring shipments by air showed that low ambient temperatures (40° to 59° F.) lessened the effects of pallet covers, precooling, and dry ice on decay and fruit temperatures in transit. A fiberboard sleeve coated with polyethylene and wax was found to retain CO<sub>2</sub> moderately well, but not as well as the polyethylene liner. Tests made toward the end of the spring season when the weather was warmer showed that less decay occurred in berries shipped in the coated sleeves (plus dry ice) than in fruit shipped in the other types of pallet loads.

Export test--Berries shipped from Santa Maria, California, required 38 hours to reach Frankfurt, Germany. Ambient temperatures were mostly in the 65-70°F. range. Top layer fruit in the pallets had temperatures approximating ambients during most of the time in transit. Middle layer fruit temperatures remained in the mid 40's. Arrival condition of most of the fruit was good, but top-layer berries suffered considerable loss of quality and had more decay than fruit in the rest of the pallet load. Dry ice placed in the top layer had all sublimed before the end of the transit period. However, 11% CO<sub>2</sub> remained in pallet loads covered with a polyethylene lined sleeve when the shipment arrived in Frankfurt and 6% CO<sub>2</sub> remained in pallet loads covered with a polycoated sleeve. (MQ 2-83)

#### E. Postharvest physiology

1. Scald Control for Apples and Pears. Various chemical and hot-water treatments applied to Stayman apples 1 or 2 days after harvest were evaluated for scald control following 5 or 6 months' storage at 32° F. Diphenylamine and ethoxyquin continued to give near perfect scald control but 30 or 60 second dips in 130° F. water also gave good protection. Scald control with hot-water dips was slightly better with warm (65°) fruit than with cool (40°) fruit and 30 seconds was safer than 60 seconds. A 30-second dip in 130° water increased core temperature about 2 degrees, and at 1/4-inch depth about 20 degrees. Heat-treated apples were hydrocooled to 35° without affecting scald control. A 30-second postharvest dip in 5,000 ppm Alar (dimethylamino-succinamic acid) gave little or no protection against scald. In one test, decay after storage averaged 9 to 14% in untreated lots and 1 to 2% in lots dipped in hot water before storage.

Scald inhibitors, DPA (diphenylamine) and ethoxyquin, when incorporated in wax, reduced scald intensity only slightly on Red Delicious apples, while plain wax intensified the scald. However, scald on Golden Delicious and Winesap apples was greatly reduced by the incorporation of either DPA or ethoxyquin in a wax coating. The best scald control of many treatments for Red Delicious apples was obtained by dipping the fruit in a water suspension of emulsified DPA and sodium-orthophenylphenate. Oiled paper wraps with ethoxyquin controlled storage scald of Golden Delicious apples completely while scald developed on 15 percent of the fruit in DPA wraps. Hot water at 125° F. for 3 minutes gave the best control of scald on Anjou pears. The next best treatment was the copper-oil wrap with added ethoxyquin. (MQ 2-91)

2. Effects of Pesticides on Storage Quality. One season's study under this P.L. 480 project in Finland was largely confined to the effects of postharvest applications of CIPC to ripening and composition of plums and tomatoes. Indicated effects of CIPC application were delayed coloring, starch hydrolysis, and ascorbic acid loss. The treatment did not cause any changes in pectin or dry weight. Much of the effort involved development of analytical methods. (E8-AMS-6)

#### F. Postharvest disease control

1. Stem End Decay in Pears. Penicillium expansum was not recovered from stems clipped from pear fruits in the orchard nor from fruit dumped at the warehouse. Pullularia pullulans, a fungus which produces an antibiotic, was recovered from the stems from both locations. There was less stem end decay in fruit dipped in Captan than in fruit treated with SOPP (sodium-o-phenylphenate) or with water at 125° F. for 3 minutes. Hot water at 130° F. for 3 minutes reduced germination of Penicillium spores by 95 percent. Four minutes' exposure at this temperature completely inhibited germination. (MQ 2-124)

2. California Grapes. Hydrocooled Emperor grapes stored at 32° F. for 10 weeks had better stem condition, color, and less shriveling than check lots that were precooled in air. Hydrocooling was done in field boxes (2 minutes) and the grapes were fumigated immediately afterwards (1.8% or 1.0% SO<sub>2</sub> for 1 or 2 minutes). SO<sub>2</sub> injury was less in hydrocooled lots than in the air-cooled lots. Ribier grapes reacted similarly, but differences between hydrocooled and check lots were smaller than in Emperors.

Thompson Seedless grapes from the early desert districts had brighter berries and greener, more turgid stems after 7 days at 40° F. and an additional 6 days at 70° when they had been hydrocooled than when precooled in air. Fruit with an initial temperature of 93° was hydrocooled to 52° in 2 minutes or to 40° in 5 minutes using 33° water. Grapes were cooled from 93° to 78° in 2 minutes with 70° water. The early grapes showed slight splitting of the epidermis when hydrocooled to 40° F. or 52° but no injury when hydrocooled to 78° in 70° water. (MQ 2-101)

3. Heat Treatment for Blueberries. Decay averaged 30% in seven lots of untreated blueberries from North Carolina or New Jersey after 2 days at 40° F. plus 4 days at 70°. A 2-minute dip in 125° water before storage reduced decay to 7%, and a 30-minute treatment in 110° air with 99% relative humidity reduced decay to 16%. Berries hydrocooled in clean water after a hot-water dip developed 17% decay, while hydrocooling in contaminated water increased decay to 80%. Berry temperatures rose to 113-123° during a 2-minute dip in 125° water. (MQ 2-104)

4. Decay Control for Strawberries. Exposure to 110° F. air of 90 or 98% relative humidity for 15 minutes and 1/2 hour, respectively, reduced decay in eastern strawberries significantly below that of the wet or dry checks during 4 days at 60° without injuring the fruit, or having any effect on

ripening or respiration of the berries. Exposure to 110° air of 50% relative humidity did not reduce decay. Dipping in 1.0 or 2.0% 2-aminobutane or exposing berries to the fumes of 0.1 or 0.2 gm/pt isomaltol also significantly reduced decay but often severely injured the caps of the berries. Dipping in 0.5% 2-aminobutane, or exposure to 0.05 gm/pt isomaltol reduced decay somewhat without injuring the fruit. (MQ 2-104)

Heat treatment of western strawberries at 111° F. for 1 hour in a water saturated atmosphere reduced decay caused by Botrytis cinerea and Rhizopus stolonifer by about 75%. Dessert quality was not impaired after simulated transit and marketing periods of 5 days at 37° and an additional 2 days at 59°.

Fresh strawberries held for 5 days at 37° F. in atmospheres with 0.5% or less oxygen had less decay than check lots, when examined immediately after storage or after an additional 2 days at 59° in air. Most of the decay was caused by Botrytis cinerea. Objectionable off-flavors developed in fruit held at oxygen concentrations of 0.25% or less. Development of off-flavors at low oxygen levels differed with the variety. (MQ 2-83)

5. Heat Treatment of Peaches. Peaches hydrocooled in water containing Monilinia or Rhizopus spores developed from 60 to 80% more decay than peaches hydrocooled in spore free water. Peaches heated in 130° F. water for 3 minutes were more susceptible to decay when hydrocooled in spore containing water than non-heated peaches or those heated in 120° or 125° water. All three temperatures reduced decay of inoculated peaches when hydrocooled in spore free water. Chlorine (100 ppm) in the hydrocooling water reduced contamination of peaches. Hot water treatment followed by hydrocooling with chlorine in the water effectively reduced decay. Hot water treatment of peaches, cooled for 24 hours at 32° F. before heating, effectively reduced decay. Water at 125° or 130° was more effective than 120° water. Internal temperatures of the precooled fruit after heat treatment were comparable to temperatures of peaches after hydrocooling. The 24-hour holding at 32° reduced Rhizopus but not Monilinia decay. (MQ 2-104)

6. Heat Treatment for Figs. Kadota figs were treated in water saturated air at 125° F. for 15, 30, or 45 minutes and stored for 5 days at 37° plus 3 days at 60°. Figs heated for 45 minutes averaged about 40% decay whereas the non-heated control averaged 85% decay. A taste panel could not detect consistent differences in flavor between the heated and non-heated figs. Black Mission figs heated 1 hour at 118° F. in water saturated air had no surface mold or decay while non-heated controls had 36% mold after 5 days at 37° plus 2 days at 60°. The taste panel could distinguish between heated and non-heated figs, but they did not find the flavor of the heated figs objectionable. (MQ 2-104)

7. Ozone Treatment of Peaches and Strawberries. Ozone applied at concentrations of 0.1 to 10 ppm for up to 6 days at 60° F. and 90% relative humidity did not reduce Rhizopus and brown rots of peaches. In concentrations above

0.5 ppm, ozone produced brown sunken areas at the stomata of peaches giving a pebbly effect on the surface.

Ozone at 0.5 ppm supplied by a commercial ozone generator capable of operating in high humidity did not improve appearance or reduce rot of strawberries stored at 35° F. and 90% RH. The caps of the berries in ozone shriveled and dried. Berries stored in ozone and tasted 3 to 6 hours after removal did not taste significantly different from those removed from air storage. (MQ 2-102)

8. Effects of Atmosphere Modification on Growth of Certain Fungi. The growth of four pathogens, Alternaria tenuis, Botrytis cinerea, Cladosporium herbarium, and Rhizopus stolonifer was reduced significantly with each decrease in oxygen concentration, when cultures were grown at 59° F. in atmospheres having 21, 1.0, 0.5, 0.25 or 0.0% oxygen. Sporulation was prevented at oxygen levels of 1.0% or less for B. cinerea, at 0.5% or less for R. stolonifer, but only at 0.0% for A. tenuis and C. herbarium. (MQ 2-112)

9. Radiation on Pathogenicity of Fungi. Fungicide resistance--Radiation induced sodium orthophenylphenate (SOPP) and sodium dehydroacetate (DHAS) resistant mutants of Penicillium expansum are genic in nature rather than due to cytoplasmic factors. Resistance to SOPP is controlled by at least 5 genes. Four chromosomes (linkage groups) are proposed for Penicillium expansum on the basis of crosses using known gene markers involved in the parasexual cycle. Cytological examinations also indicate that the nucleus in the haploid phase of this fungus consists of 4 chromosomes. All SOPP mutants were recessive while the DHAS mutants were dominant.

Host parasite relationship--Variations in availability of the amino acids methionine, arginine, leucine and histidine in the apple varieties Jonathan, Golden Delicious, McIntosh and Red Delicious influences their susceptibility to amino acid dependent mutants of P. expansum. Differences in vitamin content in these varieties apparently does not alter susceptibility. (MQ 2-96)

10. Control of P. expansum on Apples. Starking Delicious apples, inoculated with spores of Penicillium expansum were dipped in water (check), sodium-o-phenylphenate (SOPP), 5,000 ppm followed by a rinse; SOPP, 2,000 ppm without a rinse, 2-aminobutane (2AB), 5,000 ppm and thiabendazole (TBZ), 1,000 ppm. Decay after 7 days at 70° F. ranged from a high of 94.2% in the control to a low of 3.1% in the fruit treated with 2-aminobutane. SOPP treated fruit was only slightly better than the check. (MQ 2-125)

11. Aspergillus sp. on Raisins. Raisins collected from drying trays in a vineyard near Fresno, California, yielded fungi of the Aspergillus glaucus, A. flavus, and A. ochraceus groups. Subsequently, 66 samples from 16 locations in the San Joaquin Valley were cultured on agar media. Members of the A. glaucus group were identified from 46% of the samples and from 2 to 24% of the raisins in each sample were invaded. Only one sample of the 66 tested yielded A. flavus. Isolates of A. flavus grown on a water extract of raisins and incubated at 86° F. for 5 to 7 days produced moderately large amounts of aflatoxin B<sub>1</sub>. (Exploratory)

12. Apple and Pear Rots. This P.L. 480 project in Italy has been completed. The research developed useful information on symptoms, rate of growth, and product susceptibility with 4 decay organisms common in apples and pears. The Bartlett pear and Red Delicious apple proved very susceptible to lenticel infections by *Penicillium* sp., whereas the Golden Delicious apple was practically immune to lenticel infections by either *Penicillium* or *Gloeosporium*. Of preharvest sprays tried, only Captan applied 3 times during the 5 weeks before harvest was effective in reducing postharvest decays. Postharvest chemical treatments were ineffective but hot water (3 minutes at 122° F.) substantially reduced decay caused by *Gloeosporium*. (E15-AMS-2)

#### G. Prevention of insect infestation

1. Improved Pesticidal Control Methods. Malathion dust and spray protective treatments were effective against insects during the first 8 months of a laboratory evaluation test planned to run a year. Different stages of the Indian-meal moth, saw-toothed grain beetle, and merchant beetle are introduced as test insects. After 8 months there are indications that mature larvae of the Indian-meal moth are surviving the treatment on prunes and continuing their life cycle. There are also signs that merchant beetles are developing from eggs introduced into figs with the lower treatment levels. (MQ 1-15)

Malathion dust and spray protective treatments on inshell almonds in small-bin intermediate-scale tests were effective for one year in keeping heavy introduced populations of the Indian-meal moth, saw-toothed grain beetle, and merchant beetle at low levels. Insect damage to the almonds was also held to a minimum. Application rates for malathion on the whole almonds ranged from 5 to 50 ppm. The highest residues found were 7 ppm on whole almonds, 2.2 ppm on the shelled nuts before processing, and 0.8 ppm on the processed nuts. (MQ 1-27, Rev.)

Studies in previous years have shown the effectiveness of a malathion treatment on trays on which grapes are dried for protecting the grapes and raisins against insect infestation during drying and subsequent storage. Studies on the 1965 crop to determine what factors affected pickup of malathion by the raisins indicated that dry ratio, sugar content, and average daily temperature were the most significant of 11 factors evaluated. The individual importance of each is not yet known. The field studies showed that a treatment on the trays of 100 mg. per sq. ft., rather than 200 mg. as used previously, would put an adequate protective deposit into the raisins and would not exceed the Food and Drug tolerance of 8 ppm. Malathion-treated trays will be used commercially for the first time on the 1966 crop. Indications are that this will be on an extensive scale and that industry is anxious to use this new research development. (MQ 1-34)

Dichlorvos applied in a wine cellar as a thermal aerosol once a week gave good control of Drosophila, and twice a week gave very good control. Daily application with a vapor generator gave excellent control. Analysis of air samples showed that workers could safely enter treated areas one hour after the application was completed. (MQ 1-34)

A laminate of kraft paper, 1-mil polyethylene, and 0.00035-in. foil resisted insect penetration for 6 months in a test of packaging materials for dried fruit. In another test a 3-mil polycarbonate film was effective for 5 months while a 1-mil film was slightly less effective. Other less effective materials were 1-mil polyethylene, and laminates of kraft paper with  $\frac{1}{2}$ -mil polyurethane or 1-mil polyethylene, nylon, or polycarbonate. All common types of fig packages had some insect invasion within 1 month in the infestation room except a plastic cup with polyethylene cover. (MQ 1-22)

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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### Quality Maintenance in Handling and Packaging

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McColloch, L. P. 1966. Association of stem-cavity browning and brown core of stored McIntosh apples. Plant Disease Reporter 50:178-181. (MQ 2-64)

### Quality Maintenance During Transit

Harvey, J. M. 1965. Nitrogen--Its strategic role in produce freshness. Produce Marketing. July. (MQ 2-71)

### Postharvest Physiology

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Spalding, D. H. and M. Lieberman. 1965. Influence of pH, substrate, and metabolic inhibitors on ethylene production by *Penicillium digitatum*. (Abstr.) Phytopathology 55:1077-1078. (MQ 2-129)

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- Pekka Koivistoinen and Anja Karinpaa. 1965. Stability of isopropyl N-phenylcarbamate (IPC) and isopropyl N-(3-chlorophenyl) carbamate (CIPC) residues on fruit treated after harvest. *J. Agricultural and Food Chemistry* 13(5):459. (E8-AMS-1a)
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Koivistoinen, Pekka, Lasse Vanhanen, and Esko H. Koskinen. 1965. Disappearance of malathion residues from gooseberries at different residue levels. J. Agricultural and Food Chemistry 13(4):344-346. (E8-AMS-1a)

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#### Quality Maintenance in Handling and Packaging

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#### Postharvest Physiology

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## AREA 4

## GRAIN - MARKET QUALITY

Problem. Grain and cereal products are subject to damage, contamination, or deterioration in quality while in the marketing channels. These adverse effects may result from normal metabolic changes, the action of microorganisms, the attack of one or more of some 50 different kinds of common stored-product insects, or pesticide residues left by control measures applied against the insect pests. The damage may be conspicuously evident or insidiously hidden; may result in destruction of nutrient values or the presence of undesirable substances in food and feed; or insects may render products aesthetically unacceptable. Such deterioration affects the grade and price received, and end use, the wholesomeness of the product, and the competitive position of U. S. commodities in the world market. Research is needed to protect this multibillion dollar crop from outright destruction, evident deterioration, and hidden damage, especially as the need for food and animal feed becomes more critical throughout the world. The standard procedures that were formerly acceptable are becoming obsolete as a critical market demands higher quality, as international pesticide residue tolerances are in the process of being adopted, and as supply lines lengthen through overseas shipment in a worldwide distribution pattern. New methods of protection against insects and disease, of identifying and measuring quality changes, and means of maintaining quality over longer periods of time and under adverse conditions are some of the problems requiring attention.

## USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving chemists, engineers and plant pathologists engaged in basic and applied research on the quality evaluation, quality maintenance and development of objective methods for quality evaluation of cereal grains. The research is conducted at Beltsville, Maryland and also by cooperative agreement with Purdue University, Lafayette, Indiana and by a research grant with the University of Minnesota.

The Federal scientific effort in this area totals 16.7 scientific man-years: quality evaluation, 14.7, and quality maintenance 2.0.

PL 480 projects include a grant to the Institute for Cereals, Flour and Bread, T. N. O., Wageningen, Holland, providing for the development of simple, reliable and accurate tests to determine relative hardness of wheat for the purpose of devising a system of classifying wheat for use in official grading and inspection. Its duration is four years (1965-1969) and involves \$70,670 in Dutch guilders.

A grant to the Instituto Nacional de Investigaciones Agronomicas, Madrid, Spain, provides for a study to develop and evaluate equipment and methods for determining the proportions of durum (semolina) and common wheat (farina) in macaroni and spaghetti products. Its duration is five years (1964-1969) and involves \$43,563 in Spanish pesetas.

There is also a continuing program involving entomologists and chemists engaged in basic and applied research on problems of insect infestation, damage, and contamination of grains and cereal products in the marketing channels. The research is conducted at Manhattan, Kansas, and Tifton, Georgia, in cooperation with the respective State Agricultural Experiment Stations, the Transportation and Facilities Research Division, the Agricultural Stabilization and Conservation Service, farmers' cooperatives, the Association of Operative Millers, the American Corn Millers Federation and other industry groups. The Commodity Credit Corporation makes available various commodities and storage facilities for experimental use, thus greatly facilitating the program. There is also overall cooperation with several State Agricultural Experiment Stations through participation in Regional Project WM-52, "Maintaining marketability of stored grain and cereal products through insect control by methods leaving no, or a minimum of, pesticide residues."

A three-year cooperative agreement with the Kansas State University became effective in December 1965, for research on the biology and behavior of the Angoumois grain moth.

A grant to the Administration of Agricultural Reserves and Surpluses, Montevideo, Uruguay for a five-year study of underground and aboveground storage of corn in airtight silos in relation to maintaining quality and preventing insect infestation during long-term storage. It continues until May 1967 and involves PL 480 funds with a \$73,042 equivalent in Uruguayan pesos.

A grant to the Indian Agricultural Research Institute, New Delhi, India, for a three-year study of varietal resistance of wheat kernels to damage by the rice weevil and lesser grain borer. It continues until February 1968 and involves PL 480 funds with a \$15,146 equivalent in Indian rupees.

A grant to the Tokyo University of Agriculture, Tokyo, Japan for a three-year study, part of which is on the constituents of wheat that attract insects. It continues until August 1968 and involves PL 480 funds with a \$38,622 equivalent in Japanese yen.

A grant to the Hebrew University in Jerusalem, Israel, for a five-year study on the biology of the khapra beetle. It continues until October 1966 and involves PL 480 funds with a \$97,123 equivalent in Israeli pounds.

A grant to the Maharaja Sayajirao University, Baroda, India, for a five-year basic research study on the physiology of fat metabolism in relation to diapause in the khapra beetle. It continues until January 1970 and involves PL 480 funds with a \$33,907 equivalent in Indian rupees.

A grant to the University of Helsinki in Finland, for a five-year study on the effects of pesticides on plant commodities. Part of this will deal with malathion in wheat. The project continues until December 1969 and involves PL 480 funds with a \$96,441 equivalent in new Finnish finnmaks.

A grant to the Hebrew University in Rehovot, Israel, for a five-year study on the effect of ethylene dibromide fumigant on farm animals. It continues through August 1966 and involves PL 480 funds with a \$117,442 equivalent in Israeli pounds.

The Federal effort devoted to research on the prevention of insect infestation totals 7.7 scientific man-years, of which 0.1 was under a cooperative agreement.

Line Project MQ 1-31, a study on preconditioning of insects to fumigation, was terminated because the scientist resigned and no qualified replacement was available.

Line Project MQ 1-18, a study of the effects of air movement on stored-grain insects, was discontinued in July 1965.

PL 480 project E15-AMS-9(a), a study in Italy on insect infestation in pastas, was terminated upon successful completion of the plan of work.

#### PROGRAMS OF STATE EXPERIMENT STATIONS

A total of 18 scientist man-years is devoted to this area of research.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Objective Measurement and Evaluation of Quality

1. Quality Indicators for Stored Wheat. This study on objective measurements to indicate quality changes in stored wheat was completed. The study comprised four hard red spring and four hard red winter wheat varieties adjusted to 12, 14, and 16 percent moisture content and stored for various periods at temperatures of 50, 75, or 86°F. The wheats stored at the highest temperature and highest moisture content generally changed in quality at the fastest rate. The data has been tabulated and statistical analysis to determine the significance of each of the quality measurements and their inter-relationships is underway. (MQ 3-3)

2. Sampling Research. A series of tests on the performance of three commercially available grain samplers and a manually operated pelican sampler was completed. About 5,000 samples were drawn by the devices and a separate analysis performed on each. The analysis data are awaiting statistical study. (MQ 3-85)

3. Flour-Yielding Capacity of Wheat. Measurements related to the bran content of wheat have been found to be significant as indicators to flour yield in four classes of wheat. Computer analysis of our earlier data has pointed to the three most important indicators of flour yield in each class of wheat. In hard red winter: test weight, pentosan content, and mill bran account for 92 percent of the variability of flour yield. In hard red spring: test weight, pearling index, and mill bran account for 77 percent. In soft red winter: pearling index, kernel density and mill bran account for 93 percent. In white wheat: pearling index, pentosan content and mill bran account for 86 percent. Procedures combining two or more of these factors to predict flour yield will be investigated.

Rapid milling procedures, using the Brabender Quadrumat, Jr. mill, also predicted flour yield of hard red winter wheat but in the soft red winter, hard red spring, and white club wheats, the Quadrumat mill bran yield appeared to be a better indicator. (MQ 3-36)

4. Protein Content of Feed Grains. A rapid technique was developed for determining protein content in grain sorghums by measuring the change in reflectance upon adding water to the sample. The reflectance measurement was made at 640 m $\mu$  on 350 gram samples (total 157 samples) of bulk grain sorghums free from foreign material contained in a 30 square-inch sample viewing cell. This large sample viewing area permits measurement of grain sorghums which are non-homogeneous and parti-colored products with a capability of detecting 0.05 percent difference in reflectance between samples.

The dye binding test for measuring protein content in wheat was adapted to grain sorghums, barley, corn, soybean meal, cottonseed and alfalfa meal. Conversion tables with moisture corrections were prepared for each commodity. (MQ 3-58)

5. Detection of Mixed Corn. Hysteresis effects make it possible to detect lots of corn resulting from the mixing of high moisture corn with artificially dried corn. The range of moisture contents of individual kernels is found to be greater in mixtures. The greater the drying temperature, the greater is the range of moisture contents. An electronic instrument is now being built which will make rapid determinations of the moisture contents of individual kernels. Heat drying of corn causes changes in the solubility of the proteins in certain solvents. Extraction of the protein from the ground corn and determination of the protein in the extract by a colorimetric method offers possibilities as a means of detecting mixtures. This procedure is being investigated. (MQ 3-78)

6. Aflatoxin in Corn. Aflatoxin in corn is apparently associated with heat-damaged kernels. Aflatoxin was found in about 60 percent of individual heat-damaged kernels tested, but was not found in other types of damage ordinarily found in kernels of corn, such as mold, cob rot, weathered, ground, silk cut, sprouting and insects. Because of the characteristic dark red color of heat damage, the individual kernels were identified by using a simple ratio-absorbance measurement at 475 and 575 $\mu$ . This absorbance technique for identifying heat damage in kernels of corn agreed with the Grain Inspector's "eye-ball" test in all 67 kernels tested. (MQ 3-66(Rev.))

7. Quality Evaluation of All-Purpose Flour. The Perten falling number test showed considerable promise in evaluating the quality of all-purpose flour. Plans are being made by the Grain Division, Consumer and Marketing Service, (a collaborator in this project) to conduct a collaborative study of the Perten (a viscosity test) falling number determination among a selected group of cereal chemists in the United States. Large samples of all-purpose flour produced for consumer use by mills providing all-purpose flour to the Government are being obtained for additional chemical, physical and baking (bread, biscuits, cookies, etc.) tests. (MQ 3-79)

8. Macaroni and Spaghetti Products. A new chromatographic-colorimetric method, a modification of the Matweef method for measuring the different proportions of common and durum wheat flours in finished macaroni products by the presence of the sitosteryl palmitate, has shown promising results. The new method is satisfactory for detecting even low amounts of this chemical component in macaroni products. Samples of U. S. grown common (hard red winter) and durum wheats have been sent to the investigators to supplement the Spanish wheats used initially in this study. (E25-AMS-7)

## B. Quality Maintenance in Storage

1. Mycotoxin Fungi in Stored Corn. Two studies relating to the development of toxin-producing molds are currently underway. They consist of: (1) storage of high moisture field shelled corn (18 percent moisture) aerated to maintain temperatures at ambient, 30, 40, and 50°F.; (2) corn dried by the drieration process and handled in various ways in an attempt to eliminate the water condensation on the peripheral portions of the grain, associated with this method of drying.

After five months storage, there was little mold growth and no Aspergillus flavus in the corn stored at initial moisture contents of 18 percent. An exception was at the surface of the grain stored at 50°F. where the seed moisture had increased to 20 percent and was invaded by Penicillium spp.

Corn subjected to drieration, if not removed from the holding (tempering) bin even if aerated at low rates, 0.1 - 0.25 CFM/bu, molded heavily at the surface of the grain and next to the bin wall where moisture had accumulated.

Species of Penicillium were most common in all four bins examined with Aspergillus flavus and Aspergillus fumigatus occurring in one bin. Samples of dryerated corn transferred from holding bins were not molded. (MQ 2-119)

2. Quality Changes Due to Insecticides. The effect of Cab-o-sil, Silica Aerogel 68, Perma Guard, Kenite, and Malathion on test weight per bushel and yield of flour of hard winter wheat after two years' storage is unchanged from results previously reported on one-year storage. For all treatments, except Malathion, there is an initial but no subsequent decrease in test weight. Flour yield is unaffected. The Cab-o-sil, Silica Aerogel 68 and Perma Guard treated samples of hard winter wheat increased in fat acidity values to about the same level as the control. Increases were less for the Kenite and Malathion treated samples. Marked decreases were shown in the mixing tolerance values by the farinograph for the control and four of the insecticide treated samples, but this dough property increased for the Cab-o-sil treated wheat. The breads from the Perma Guard, Kenite and Malathion treated samples decreased in loaf volume (rich formula method without dry skin milk) during the two-year storage period.

In a cooperative study with the Stored-Products Insects Branch, Market Quality Research Division and the Human Nutrition Research Division on quality changes due to fumigation, two controls (identified as outside and cold) and three fumigated wheat samples treated with (1) phosphine; (2) methyl bromide, and (3) three parts of ethylene dichloride plus one part carbon tetrachloride comprise the samples in this study. No changes have taken place in the chemical and milling characteristics at the end of nine months storage as compared with the initial tests. The absorption and mixing peak values, according to the farinograph tests, increased gradually with storage time for the fumigated and control samples. Fumigation treatment improved the dough mixing tolerance, another important quality property, to a greater degree than the control samples. Phosphine and methyl bromide treated samples were best of the group in this respect after nine months storage. There were no significant differences in bread loaf volume between the controls or the fumigated wheats. Bread loaf volume, crumb grain and color decreased with length of storage time; the losses were small and gradual and about of equal magnitude for the fumigated as the control samples. The hot breads from the fumigated samples were normal in odor. (MQ 2-70)

3. Microflora of Wheat. The final report on this project presents considerable data on the biochemical and technological properties of stored soft wheat and flour milled therefrom. Physical properties of the doughs are stated to improve with storage resulting in better loaf volumes. Diastatic activity (maltose) of the grain underwent a gradual decrease under all conditions of storage. A positive correlation between fat acidity values and loaf volume was found in 8 of 12 cases involving wheat stored under different conditions of temperature and relative humidities. Stability of the flour was found to depend not only upon the conditions of storage

but also upon the mode of preparatory treatment of the grain prior to milling. Leveling off and/or a decrease in fat acidity values with time of storage in some of the Polish studies is explained as related to development of molds. (E21-AMS-7(k))

### C. Prevention of Insect Infestation

1. Biological and Physical Control. In tests with corn in 500-bushel bins in Georgia a silica aerogel dust continued to give protection comparable with that from malathion 32 months after treatment. The effectiveness of both materials decreased considerably between the 24- and 32-month inspections. Another silica aerogel and two diatomaceous earths were less effective. The lesser grain borer was the predominant insect in the inert dust-treated corn and the rice weevil in the malathion treatment. Malathion residues were 1.2 ppm at 24 months and 0.9 ppm at 32 months, indicating the treatment has reached the breaking point of protection. Bioassay tests showed that the inert dusts were only about half as repellent at 24 months as at 12 months. In field tests in Kansas, where thirty 3,250 bushel-bins of wheat were sampled regularly over a 30-month period, observations indicated that diatomaceous earth and silica aerogel wheat treatments were nearly as effective as malathion in preventing insect buildup in dry wheat. Observations also indicated that the inert dust treated wheat tended to retain moisture from leaks during snow and rain storms, causing spoilage and insect development in localized areas. (Unclassified)

Adherence of inert dust to grains during treatment in the laboratory depends on kind of dust and variety of grain. Grain sorghum and wheat retain equal amounts of the same dust while less remains on shelled corn. Silica aerogels and diatomaceous earths were evaluated. Toxicity studies with 12 percent moisture wheat, which was aged for 9 months following treatment with 2 diatomaceous earths, Perma Guard and Kenite 2-I, showed kills of rice weevils comparable to newly-treated wheat. The repellent action of these two materials on wheat was not measurably reduced after 24 months of aging. (MQ 1-15)

Ninety-seven selected double crosses of corn with F44 as one of the parents, were rated for rice weevil resistance during storage. Lines crossed with F44 as the female parent were considerably more resistant to rice weevil invasion than were reciprocal crosses of the same lines. When F44 was used as the female parent, no rice weevil progeny developed on nine of the 65 crosses. The number of progeny from the others averaged 0.2 to 8.2. Average progeny from reciprocal crosses averaged 1.6 to 52.6. In tests with 65 crosses with F6 as one parent the resistance was not as great, no progeny from only one cross and ranging to a high of 28.0. Average progeny from crosses of some of these lines ranged from 1.6 to 75.8 rice weevils. In 70 crosses with GT 112 as one parent there was even less resistance, progeny averaging 4.6 to 99.0. In tests with 49 varieties grown in Corn Performance Field Crops Variety Trials, none of the hybrids was resistant to rice weevils, progeny averaging 87.0 to 282.0. (Cooperation with Georgia Agricultural Experiment Station)

The final report from the study of insect infestations in spaghetti, macaroni, noodles and other pastas lists seven significant findings or accomplishments. These are: (1) the process of milling wheat destroys internal infestations; (2) Sitophilus oryzae and S. granarius cannot subsist in flour; (3) the pressure to which dough is subjected in modern pasta presses is sufficient to kill Sitophilus sp. eggs; (4) the high temperatures inside pasta driers are sufficient to kill eggs that are present and to prevent egg-laying; (5) infestation can occur only after the pasta is made; (6) pasta may become infested while stored at the mill, during warehouse storage, in transit, and while on the grocery shelf, and (7) valuable contributions were made to insect-rearing methods and on the biology of the two species of Sitophilus. The project has been satisfactorily completed and three articles published reporting the results. (E15-AMS-9(a))

2. Biology, Ecology, and Physiology. Nine different antibiotics tested individually in several percentages in the diet of khapra beetle larvae had varying effects on length of larval development, from none to a considerable delay in development with the lower percentages of tetracyclin and tyrothricin. A pheromone was collected from virgin female adult khapra beetles by extraction in diethyl ether or by allowing the females to crawl on filter papers. Both sexes of the beetle are attracted by the pheromone, classing it as an aggregating substance rather than a sex attractant. Virgin females were more strongly attracted than were virgin males or females after copulation. Preliminary tests showed that larvae of the khapra beetle detect light in the range from red to violet. Extensive tests have been conducted and much has been learned about response to different wave lengths and intensities of light and this work is continuing. Khapra beetle adults preferred the dry end of a long humidity gradient chamber. From 54 to 60 percent gathered in the end with a range from 0 to 10 percent relative humidity. The response varied with sex and age. In temperature gradient studies, 70 to 80 percent of the adults preferred the range between 78 and 88°F., although about 15 percent were in the area of 96 to 98°F. (A10-AMS-11(k))

A temperature of 95°F., a relative humidity of 70 percent, and crushed wheat as a rearing medium were found to be the most suitable conditions for obtaining non-diapausing specimens of the khapra beetle in a fat-metabolism study. The fat body of 5th-instar larvae contains large amounts of lipids and some albuminoid-like globules. No uric acid was demonstrated in the fat body at this stage. During the course of this study, a protozoan was found to parasitize the khapra beetle larvae, causing considerable mortality. This organism might well be a potential agent for control of the insect. (A7-MQ-3(a))

3. Improved Pesticidal Control. Chloropicrin fumigation by the recirculation method of application was highly effective in a test conducted in a large flat storage building containing 100,000 bushels of wheat. The dosage applied was 2 pounds/1,000 cubic feet, recirculated for two hours. Average mortality of test insects in 112 locations was 94.8 percent for adult confused flour beetles and 99.2 percent for immature rice weevils. The

principal areas of insect survival were midway between the aeration ducts at each end of the building. Static pressure readings showed there was little air movement in those locations. Gas chromatographic analyses of air samples from the same locations revealed low chloropicrin concentrations there, but good distribution elsewhere. There was no evidence of the gas settling out of the grain during 24 hours after application. (MQ 1-16)

Newly combined wheat with a moisture content of 13 to 14 percent was effectively protected against insect infestation by malathion or diatomaceous earth during the first 12 months of storage in 100 bushel wooden farm-type storage bins in Kansas. (MQ 1-27(Rev.))

The effectiveness and persistence of a fresh malathion treatment on wheat was not altered by aeration for five weeks at conventional airflow rates of 0.05 or 0.1 c.f.m./bushel, with the air at 80°F. and 75 percent relative humidity. When the wheat had been treated with malathion four months prior to aeration, effectiveness of the malation declined after only two weeks of aeration. Air drawn from malathion-treated wheat was highly toxic to rice weevils at first and progressively declined in toxicity during five weeks of aeration at conventional airflow rates. Air drawn at a high flow rate remained nearly as toxic to rice weevils after four weeks of aeration as it was during the first week. (Exploratory)

In preliminary tests, two treatments show promise as economical and effective means of dealing with the difficult problem of insect infestation in rail cars. For empty cars, one quart of a mixture containing  $2\frac{1}{2}$  percent of malathion and  $2\frac{1}{2}$  percent of dichlorvos is applied with 100 p.s.i. of air pressure to make a heavy, wet fog. It is directed behind the car liners and onto the inner surfaces of the car. The pressure blasts the spray into almost impenetrable cracks and crevices. Total time for treatment and aeration is 20 minutes per car and the material costs less than 60 cents. So far, 100 percent of test insects have been killed. For rail cars loaded with packaged cereal products and for loaded bulk hopper car, fumigation with aluminum phosphide pellets at the rate of 165 per 1,000 cubic foot has given excellent results. (Exploratory)

Two tests conducted in quonset huts each containing 18,000 bushels of shelled yellow corn showed that fumigation can be accomplished by putting aluminum phosphide tablets on the surface of the grain rather than probing them in by the conventional method. The dosage rate was 90 tablets per 1,000 bushels and in one test there was 93.8 percent mortality of immature rice weevils and 99.9 percent mortality of adult red flour beetles. (Exploratory)

Aluminum phosphide pellets at 165 per 1,000 cubic foot and tablets at 45 per 1,000 cubic foot have excellent control of insects inside packaged food products stacked on pallets and covered with polyethylene sheets for fumigation. Several common types of packages were included, some of which were plastic films and foil-laminated over wraps. There was 100 percent

mortality of rice weevil adults, confused flour and saw-toothed grain beetle adults, dermestid larvae, and Indian-meal moth larvae. The kill of immature rice weevils was only about 99.9 percent but this stage would not infest most packaged food products. (Exploratory)

By utilizing air movement, malathion aerosol in quantities lethal to insects has been pulled down through as much as 14 feet of shelled corn. Compaction of the grain influences airflow and rate of airflow in turn affects the distribution of the aerosol through the grain mass. (Exploratory)

In a study to determine the effect of ethylene-dibromide-(EDB)-fumigated feed on animals, analytical methods developed on the projects using minute quantities of sample were used to establish curves of aeration time required for a fumigant mixture applied to wheat, barley, and corn. It appears that the effect of EDB on laying hens was not related to gonadotropin deficiency since treating hens with a follicle-stimulating hormone did not improve depressed egg weights. The chemical composition of small eggs from hens fed on EDB-fumigated feed was similar to normal eggs as far as total nitrogen, calcium, phosphorus and fat were concerned. Only the total amounts of yolk constituents seem to be affected. The semen apparently is not affected by treatment of cocks with EDB. The influence on bull semen was stronger when the EDB was administered in double doses every second day, than in single daily doses. In the study of acute poisoning of rats by EDB, the structure of the main metabolites in urine was clarified. (A10-AMS-4(a))

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

##### Objective Measurement and Evaluation of Quality

Baker, Doris, and C. Golumbic. 1966. Estimation of flour-yielding capacity of wheat. Presented at Fourth International Cereal and Bread Congress, Vienna, May. (MQ 3-36)

Johnson, R. M. 1966. A rapid test for flour quality. American Miller and Processor 94:30, May. Agricultural Marketing, May. (MQ 3-3)

Johnson, R. M., and A. S. Kozak. 1966. Correction for the effect of diatomaceous earth on moisture content of wheat as determined by capacitance measurements. Agronomy Journal 58:2, March-April. (MQ 3-70)

##### Quality Maintenance in Storage

Johnson, R. M. 1965. Maintenance of dry bean quality during transportation, handling and storage. Seventh Research Conference on Dry Beans pp 20-23, July. ARS 74-32. (MQ 2-3)

## Prevention of Insect Infestation

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- Golumbic, C., and D. F. Davis. 1966. Radiation disinfection of grain and seeds. Preprint No. SM 73/69 for International Symposium on Food Irradiation, Vienna, Austria, June 1-10, 1966. (MQ 1-12)
- Harein, Phillip K., and Hayen B. Gillenwater. 1966. Exploratory tests with bromodan as a protectant for wheat against stored-product insects. *Jr. Econ. Ent.* 59(2):413-414. (MQ 1-15)
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- White, G. D., W. L. Berndt, J. H. Schesser, and C. C. Fifield. 1966. Evaluation of four inert dusts for the protection of stored wheat in Kansas from insect attack. U. S. Department of Agriculture, ARS 51-8, 21 pp., June 1966. (MQ 0-0-1(CCC))

#### PUBLICATIONS -- STATE EXPERIMENT STATIONS AND COOPERATIVE PROGRAMS

##### Objective Measurement and Evaluation of Quality

- Barmore, M. A., and R. K. Bequette. 1965. Weight per bushel and flour yield of Pacific Northwest white wheat. Cereal Science Today 10(3): 72-77. (Washington)

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## AREA 4a

## RICE - MARKET QUALITY

Problem. Harvested rice is subject to damage or deterioration in quality while in marketing channels through normal metabolic changes, by the action of disease organisms, and by insect infestation. There is need for developing more effective ways of preventing insect infestation during storage, handling, processing, packaging, and transportation of rice. Attention must be given to finding control methods that will minimize or eliminate pesticide residue hazards. To maintain the quality of rice, more precise information is needed on the changes that occur in handling, storage, and transportation. To insure uniform and standardized products and more equitable prices to all concerned, new and improved procedures for measuring quality factors must be developed for use in inspection, grading, and standardization operations.

## USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving engineers, chemists, and plant pathologists in basic and applied research on the quality evaluation and quality maintenance of rice. This work is located at College Station, Texas, in cooperation with the Texas Agricultural Experiment Station.

The Federal scientific effort in this area totals 2.0 scientific man-years: quality evaluation 1.0, and quality maintenance 1.0.

A grant to the Department of Plant Chemistry, Valencia, Spain, provides for a study on storage changes in milled rice and their relation to market quality. Its duration is for 4 years, 1964-1968, and involves P.L. 480 funds with a \$62,479 equivalent in Spanish pesetas.

A grant to the National Institute of Hygienic Sciences, Tokyo, Japan, provides for a study covering the cause and development of mycotoxins in rice as a result of invasion and growth of fungi during postharvest conditioning, handling, and storage. Its duration is 3 years (1965-1968) and involves \$33,164 in Japanese yen.

There is also a continuing program of basic and applied entomological research directed toward the prevention of insect infestation in rice in the marketing channels, headquartered in Fresno, California. The Federal effort was temporarily reduced to only 0.5 scientist man-year by assignment of personnel to research on gamma irradiation, which is also pertinent to insect infestation in rice. Much of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is applicable to the problems in rice.

A grant was made to the Tokyo University of Agriculture, Tokyo, Japan, for a 3-year study, part of which is on the constituents of rice that attract insects. It became effective in August 1965 and involves P.L. 480 funds with a \$38,622 equivalent in Japanese yen.

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 2 scientist man-years is devoted to this area of research.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Objective measurement and evaluation of quality

1. Degree of Milling and Color of Rice. A commercial transmittance instrument, the "Ratiospect," was modified by adding a reflectance attachment and special optical unit. The optical unit is arranged to permit either reflectance or transmittance measurements of a rice sample to be made by moving a selector lever. Degree of milling, degree of parboiling and color measurements made on a large number of graded rice samples with the modified "Ratiospect" show that correlation between instrument readings and visual grades were high for white milled rice but somewhat lower for parboiled rice because of interactions between degree of milling and degree of parboiling. (MQ 3-82)

##### 2. Environmental Conditions and Stress-Cracks in Milled Rice.

Instrumentation and techniques were developed to measure stress-crack damage in milled rice caused by environmental changes (temperature and relative humidity). The results showed the following: (1) high-moisture rice is more susceptible to damage than low-moisture rice; (2) rice subjected to a relatively small change in relative humidity (20 percent) is severely damaged when the temperature of the new atmosphere is relatively high, 30° C. or more, and (3) the amount and rate of damage is directly related to the magnitude of the change in moisture content the rice would undergo if allowed to come into equilibrium. Varieties differ greatly in their susceptibility to stress-crack damage, from a relative value of one for Century Patna 231 to a value of over 12 for Blue Belle. (MQ 3-68)

##### B. Quality maintenance in conditioning, handling and storage

##### 1. Microbiological, chemical, and Physical Deterioration of Rough Rice.

The relation between storage relative humidity and the rate of establishment of infection was studied by inoculation of rough rice with the dry spores of an isolate of the Aspergillus flavus group and subsequent storage at 30° C. and relative humidities ranging from 70 to 90 percent. Infection occurred at a high rate at all relative humidities during the first week of storage. Competition by other fungi had little or no effect on the prevalence of infection by A. flavus in the rice stored in relative humidities of 70, 73, and 75 percent for periods up to 4 weeks. Members of the A. glaucus group

became increasingly competitive as the storage relative humidity was increased from 80 to 90 percent. A. candidus became increasingly competitive after 21 days of storage at 87 percent R. H. and after 14 days at 90 percent. The prevalence of Penicillium spp. also started to increase rapidly after 21 days of storage at 90 percent.

These data provide additional evidence that prevalence of fungi in rough rice as determined by isolations from kernels or colony counts by the dilution method is an inadequate method of estimating the effect of fungal invasions on deterioration or changes in quality. Studies to relate the rate of CO<sub>2</sub> evolution with fungal induced changes in quality during storage are in progress. (MQ 2-7(Rev.))

2. Heat Damage of Rice. Asperigillus fumigatus was investigated as a possible cause of heat damage. Although the fungus grew well on rough rice at temperatures ranging from 40 to 50° C. and caused a general deterioration of the grain, heat damage symptoms or other distinctive kernel discoloration did not develop. Rough rice inoculated with A. parasiticus developed some heat damage symptoms but all tests gave widely variable results and must be considered as inconclusive. (MQ 2-76)

3. Damage and Off-Color in Rough Rice. Discolored bran in second-cutting Belle Patna rice was found to be caused by infection by Helminthosporium oryzae. The somewhat atypical discoloration appeared to result from infections initiated in kernels in the latter stage of maturity. (MQ 2-77)

4. Storage Changes in Milled Rice. A highly significant positive correlation has been found between the disulphide groups content and the quality of milled rice. This relationship is evident in both fresh and stored rice. Microbiological respiratory activity was not indicated as a major cause of changes in quality in milled rice during storage. Preliminary data show that gelatinization and pasting characteristics are not useful for evaluating cooking quality changes in rice during storage. The N index of objective measurement of quality is a valid method of evaluating stored as well as fresh milled rice. (E25-AMS-9)

5. Mycotoxins in Rice. The production of aflatoxins in high moisture rough rice was studied in early, mid-season, and late harvested rice in cooperation with the T&F Division. These tests clearly showed that all other factors being equal, aflatoxins can be expected to develop most rapidly in high moisture rice held under the higher temperatures prevailing during the early harvest. Extensive investigations in the laboratory of the effect of temperature in the development of aflatoxins in rough rice have supplied verification. Although there are some slight differences in response to temperature among various strains of the A. flavus group, optimum temperature for aflatoxin production ranges from 20 to 35° C. Moreover, the most important aspect of the temperature/aflatoxin relationship is that production and accumulation increases sharply as the temperature increases within the optimum range. As an example, 6 days at 20° C. were required for aflatoxin concentrations to reach the level obtained in 2 days at 30° C. in one such test. (MQ 2-103)

About 170 isolates of fungi have been obtained from 136 samples of milled and rough rice from 92 locations in Japan. Preliminary tests of acute toxicity of culture extracts have been made by oral administration of .02 ml of an extract to two-week-old mice. Some strains of Aspergillus flavus, A. ochraceus, A. clavatus, and Penicillium islandicum were characterized by high toxicity in this test. (All-MQ-2)

### C. Prevention of insect infestation

1. Biological and Physical Control. Increasing the intensity of infrared radiation applied to rice internally infested with immature stages of the rice weevil, lesser grain borer, and Angoumois grain moth caused a proportionate increase in insect mortality, even though the total dosage of radiation was held at the same level. (MQ 1-9)

Rice weevils and lesser grain borers showed a definite preference for feeding on certain varieties of rice in tests where the results were based on a evaluation of the amount of damage to kernels. (Exploratory)

In olfactometer tests rice weevils were more strongly attracted to polished rice than to rough rice. The attracting substances were extracted more readily with methanol than with ether. The methanol extracts from rice bran were more strongly active than the ether extracts. (All-MQ-3)

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

### Objective Measurement and Evaluation of Quality

Primo, E., S. Barber y A. Garcia. 1965. Factores de calidad del arroz. XV. Efecto del desengrasado parcial sobre la calidad. Rev. de Agroquímica y Tecnología de Alimentos 5(1): 106-112. (E25-AMS-9)

Primo, E., S. Barber, y C. Benedito de Barber. 1965. Factores de calidad del arroz. XVI. Influencia de los grupos sulhidrido y disulfuro. Rev. de Agroquímica y Tecnología de Alimentos, 5(2): 232-238. (E25-AMS-9)

### Quality Maintenance in Conditioning, Handling and Storage

Schroeder, H. W. 1965. Fungus deterioration of rice: Effects of fungus infection on free amino acids and reducing sugars in white and parboiled rice. Cereal Chem. 42: 539-545. (MQ 2-7(Rev.))

Schroeder, H. W. 1965. Changes in the composition of rice associated with kernel infection by Helminthosporium oryzae. Proceedings 10th Rice Technical Working Group. 57-58. 111 pp. (MQ 2-77)

Schroeder, H. W., and S. F. I. Fazli. 1965. Panicle infection of rice by Helminthosporium oryzae. Proceedings 10th Rice Technical Working Group 63-64. 111 pp. (MQ 2-7)

Schroeder, H. S., and R. A. Stermer. 1965. Market quality research of rice in Texas, 1964-1965. Rice Journal 68: 9-11, 27. (MQ 2-7(Rev.))

Prevention of Insect Infestation

Tilton, Elvin W., and Robert R. Cogburn. 1965. Phosphine fumigation of rough rice in upright bins. Rice Journal 68(11): 8-9. (BS 1-30)

PUBLICATIONS -- STATE EXPERIMENT STATIONS  
and COOPERATIVE PROGRAMS

A. Objective Measurement and Evaluation of Quality

Hall, Vernon L. 1965. Some aspects of rice quality investigation. Rice J. 68(7), pp. 46-47. (Ark.)

## AREA 4b

## FEED AND SEED - MARKET QUALITY

Problem. Many methods of determining seed and feed quality currently in use require too many man-hours, impose tedious work on the analyst, are incapable of high degrees of standardization, and do not provide accurate indices of quality. Practical methods are needed for determination of such quality factors as mechanical purity, genetic purity, germination, vigor, weed seed content, protein content (of feeds) and infection with disease organisms. The deleterious effects of high temperatures and relative humidities on stored seed are well known but little is known about the part played by storage molds, especially the minimum temperature-relative humidity combinations under which the storage molds survive in stored seed. There is urgent need to increase basic research which would serve as a basis for developing more practical methods of determining seed and feed quality and for recommending improved practices of storing seed.

## USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-time program on seed research involving botanists, plant physiologists, plant pathologists, engineers, and chemists engaged in both basic and applied research on quality evaluation and quality maintenance of seed. This research is conducted at Beltsville, Maryland, and College Station, Texas, and by research contract with the Oregon Agricultural Experiment Station and by cooperative agreement with Mississippi State University.

The Federal effort in this area totals 6.2 scientific man-years: quality evaluation, 5.5, and quality maintenance, 0.7.

A PL 480 grant with the Instituto Biologico, Sao Paulo, Brazil, provides for a study of substrate moisture levels for germination testing of agricultural seeds. The project runs from 1961 to 1966 and involves \$31,016 equivalent in Brazilian cruzieros.

A PL 480 grant with Rijksproef-station, Wageningen, Netherlands, provides for a study of the health condition of seeds in commercial channels and development of methods suitable for routine testing for seedborne organisms. The duration of the project is five years, beginning 1963, and the total grant in Dutch guilders is the equivalent of \$55,918.

A PL 480 grant with Samenprüfstelle, Munster, Germany, provides for a study of the biological and environmental factors affecting the physiological maturity of grass seeds. The duration of the project is three years, beginning April 1965, and the total grant in German marks is the equivalent of \$31,775.

A PL 480 grant with Forschungsgemeinschaft für Saatgutforschung, Reutlingen, Germany, provides for a study of methods for maintaining the germination of seeds in storage and in trade channels. The project has a duration of five years, beginning April 1965, and the grant in German marks is the equivalent of \$52,338.

A PL 480 grant with the Agricultural Research Station, Beit Dagen, Israel, provides for research to find a satisfactory invisible marker of seeds in commercial channels and for research purposes. The project runs for three years, beginning February 1965, and the total grant in Israeli pounds is the equivalent of \$45,640.

A PL 480 grant with the Indian Agricultural Research Institute, New Delhi, India, provides for a study to evaluate the X-ray technique for detecting empty seeds in purity testing and for determining seed viability. Its duration is five years, beginning October 1965, and the total grant in Indian rupees is the equivalent of \$37,464.

A PL 480 grant with the Weizmann Institute of Science, Rehovoth, Israel, and the Hebrew University, Jerusalem, Israel, provides for research to isolate and determine the structure of germination inhibitors in seeds. The project runs for three years, beginning October 1964, and the total grant in Israeli pounds is the equivalent of \$50,722.

A PL 480 grant with the Israel Institute of Technology, Haifa, Israel, provided for a study to develop tests for nutritive value of cereals grains and feeds. The duration of the original grant was four years, 1961-1965, but an extension of one additional year was approved. The total grant involved an expenditure of \$53,298 equivalent in Israeli pounds.

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 4 scientist man-years is devoted to this area of research.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Objective Measurement and Evaluation of Quality

1. Development and Standardization of Seed Testing Equipment. Laboratory models of a seed blower, for semi-automation use, utilizing the Venturi principle, and a seed subsampling device with an air-operated seed transfer sleeve for recycling all seed not drawn off in the subsample were designed

and constructed. Of several air measuring devices used to calibrate a seed blower for precision separations, a thermo-anemometer was the only one with potential value but it was not completely successful. (MQ 3-21(C)(Rev.))

2. Seed Metabolism. By kinetic analysis in vivo and in vitro, it was shown that the "activation" of ribosomes parallels for formation of polysomes throughout the early phases of wheat embryo germination. The initial reaction is extremely rapid and manifests itself approximately ten minutes after water uptake. This "trigger" reaction has been obtained in vitro and may be described as an ATP-requiring messenger RNA-ribosome binding system. (MQ 3-32)

3. Determining the Purity of Certain Grass Seeds. Methods of overcoming the detrimental effect on germination of some grass seeds caused by solvents used in the flotation purity analysis were studied by the following methods: (1) Froth flotation using a special flotation cell; (2) Use of supplemental drying treatments, and (3) Use of low-surface tension aqueous solution for flotation. Promising results were obtained with a combination of these methods, but further tests are needed for conclusive results. (MQ 3-39)

4. Hay Moisture Meter. Good results were obtained from the conductance hay moisture meter which was field tested by the Dairy Science Departments, University of Maryland, and Texas A&M University, in 1965. Several instrument manufacturers have indicated an interest in manufacturing the meter for commercial sale. Over 500 requests for copies of USDA ARS 51-2 were filled during the past two years which indicates the amount of public interest in the moisture meter. (MQ 3-41)

5. Development of Seed Germinator. Tests with the new germinator showed several minor modifications to be necessary. A programmed temperature control for the coolant liquid was designed to prevent overshoot in cooling. Improvement was made in light uniformity and intensity levels over commercial germinators presently in use. Humidity and temperature control appear to be excellent based on limited tests of the new germinator. (MQ 3-48)

6. Processing Grass Seed for Laboratory Testing. Extensive tests made with a modified McGill rice sheller to dehull the caryopses of sideoats grama and orchardgrass showed that the mechanical method (1) measures the purity with somewhat higher sensitivity than the official method; (2) is twice as fast as the hand method; (3) does not require a highly trained seed analyst, and (4) provides shelled seed that germinate in one-half to two-thirds the time required for unshelled seed. Limited tests show the method is equally well suited for big bluestem, little bluestem, and blue grama. (MQ 3-54)

7. Seed Vigor. Respiration measurements were highly correlated with the vigor of corn seed which had been stored under various conditions of temperature and humidity for four years. Respiration also detected weak lots of cabbage, onion, and tomato seeds; and revealed desiccation-induced dormancy in sorghum. Calculation of R. Q. (carbon dioxide evolution/oxygen

uptake) ratios and the use of an oxygen atmosphere during the respiration tests sometimes revealed weak seed lots more effectively than simple determinations of oxygen uptake, especially in tests performed during the initial 2-4 hours of germination. Arrangements were made with the Seed Branch of the Grain Division, Consumer and Marketing Service, for conducting practical tests of seed vigor by the respiration method. (MQ 3-55)

8. Verification of Varietal Designations of Crop Seeds. Electrophoretic analysis of protein extracts from 65 soybean varieties revealed an outstanding difference among the varieties, based on two banding patterns, tentatively called A and B. Each variety consistently contained proteins which produced either an A or B banding pattern. F<sub>1</sub> progeny of crosses between A and B type varieties yielded both A and B proteins. Pubescence color of soybean seedlings was intensified and more easily detected when continuous high-intensity light was used in a growth chamber.

Extracts from perennial ryegrass seed contained a distinctive protein not found in annual ryegrass seed. It is possible that this protein difference may form the basis for a practical test to distinguish between seed of the two species. (MQ 3-64)

9. Detection and Identification of Seedborne Pathogenic Fungi. The influence of 128 culture media, consisting of a basal Czapek's medium to which were added different combinations of 32 carbon-containing compounds and four nitrogen-containing compounds, on the growth of 30 seedborne parasitic and saprophytic fungi were examined. Although a final evaluation of the data will not be possible until a statistical analysis has been completed, it is apparent that no selective action was obtained with any of the culture media used. (MQ 3-67)

10. Environmental Control of Seed Dormancy and Germination. Seeds of two ecotypes of Eragrostis curvula were similar in their germination responses. Both germinated well in continuous light following a dark imbibition period and less well when the dark period was interrupted briefly by red light. Phytochrome control was clearly evident because far red irradiation completely nullified the inhibitory effects of red. The two ecotypes differed as follows when exposed to 29°C.: (a) Lot 1 seeds germinated when placed in continuous light, while Lot 2 seeds required a long dark period; (b) after dark-treatment, Lot 1 seeds responded to a brief exposure to red light while Lot 2 seeds still required a long period of continuous or intermittent light for germination. These results emphasize their importance of small variations in light and temperature for successful germination of light sensitive seeds.

11. Germination Inhibitors in Seeds. Extracts of barley seeds yielded the following compounds which were identified and found to inhibit the germination of lettuce seeds: P-hydroxybenzoic acid, P-coumaric acid, P-hydroxybenzaldehyde, and vanillin. At least five other acids of phenolic character were found, but these have not been identified. (A10-MQ-1)

12. Biological and Environmental Factors Affecting the Physiological Maturity of Grass Seeds. The first six-month report indicates that seeds of orchardgrass and annual ryegrass harvested in the dough stage gave higher germinations than when harvested in full ripe stage. Seeds of meadow fescue and Kentucky bluegrass did not exhibit this phenomenon. All results are tentative. (E10-MQ-3(a))
13. Development of Methods Suitable for Routine Testing of Seed for Seedborne Organisms. In previous research under this grant, significantly fewer seed-borne fungi developed in germination tests when the blotters were kept wet than when kept slightly dry. Research during the past year showed that this effect is due to an antagonistic effect of bacteria. A screening test for seedborne fungi on wheat grown in the Netherlands showed that Fusarium nivale was the most prevalent pathogen; however, the less prevalent fungi, F. graminearum and Septoria nodorum, appeared to be more serious to the growing crop. (E19-AMS-11(a))
14. Moisture Levels for Seed Germination. Seeds of a number of species germinated equally well over a range of moisture levels; thus, no specific amount of moisture was found to be optimum for germination of seeds of the species used in this study. Using a standard experimental procedure, the following kinds germinated equally well over the indicated range of moisture levels (i.e., number of ml of water added to 400 g of uniform sand): Peanut, 70-85 ml; sorghum, 15-55 ml; watermelon, 30-80 ml. The speed of germination of rice was retarded by the addition of excess water during the first three days of test; however, the total germination was not affected when the seedlings were evaluated 10-14 days after planting. Addition of excess water after three days from planting date had no influence on the speed of germination. (S3-AMS-2(a))

#### B. Quality Maintenance in Storage

1. Microbiological Deterioration of Grass Seeds During Marketing. Storage of four species of grass seeds under 16 different levels of temperature and relative humidity revealed that freshly harvested seeds of Kentucky bluegrass, red fescue, tall fescue, and annual ryegrass apparently harbor storage fungi that are in a dormant state. Plating-out on agar seeds of these grasses before and after storage for three months at 30°C. and 75 percent relative humidity revealed no storage fungi prior to storage, but numerous storage fungi after the storage period. To separate the effects of processes inherent in seeds from the effects of microorganisms while studying the effects of storage environment on seed germinability, it is necessary to use seeds free of storage fungi. Since it is not possible to obtain grass seeds from the field free of storage fungi, efforts are being made to produce a supply of germ-free seeds. (MQ 2-62)

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## AREA 5

## LIVESTOCK AND MEAT - MARKET QUALITY

Problem. To insure that grades are a true measure of palatability, a better understanding of the relationship between the physical and chemical properties of muscle and quality must be established. This information can then be used to devise objective methods for measuring the degree of tenderness, juiciness, and flavor in meat cuts.

The dominant method of merchandising meat in retail stores today is through the use of self-service display cases. Therefore, quality and appearance of the meat is of primary importance and research on maintaining meat quality and shelf-life is a necessity for the success of this type of merchandising. Lighting conditions required to evaluate meat quality need to be defined so that the meat quality attributes can be properly assessed.

The maintenance of desirable meat quality during various transport techniques and the determination and evaluation of the various methods of shipping fresh meats to European markets are primary research needs if we are to expand our market for fresh meats.

## USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving chemists and food technologists in basic and applied research on quality maintenance, and development of objective methods for quality evaluation of meat. This work is conducted at Beltsville, Maryland, partly in cooperation with the Animal Husbandry Research Division, Agricultural Research Service, the Livestock Division, Consumer and Marketing Service, the Radiological Laboratory of the Johns Hopkins Medical Institutes, and Texas A&M, and partly by contract with the Universities of Wisconsin, Illinois, and Texas A&M.

The Federal scientific effort devoted to research in this area exclusive of contract research totals 7.9 scientific man-years divided as follows: quality evaluation, 6.9, and quality maintenance, 1.0.

A research grant to the Research Center of the Meat Industry, Helsinki, Finland, provides for a study on the effects of carbon dioxide or nitrogen on chemical and physical properties of refrigerated meats. Its duration is four years, 1963-1967, and involves PL 480 funds with a \$44,454 equivalent in Finnmarks.

## PROGRAM OF STATE EXPERIMENT STATIONS

A total of 20 scientist man-years is devoted to this area of research.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective Measurement and Evaluation of Quality

1. Relationship of Marbling to the Palatability of Beef. A correlation appears to exist between the concentration of phospholipids, triglycerides and tenderness as measured by mechanical tests and by taste panels. As the ratio of phospholipid to triglyceride increases, tenderness decreases. More than 80 percent of the measurements made follow this pattern. Contribution of the fatty acid composition and soluble and insoluble collagen factors to tenderness are under study.

Rapid non-chromatographic procedures have been developed for separating total lipids into phospholipids, triglycerides and free fatty acids and improvements have also been made in determining the fatty acid composition of these classes. (MQ 3-60)

2. Objective Methods for Measuring Maturity. Studies of beef and chicken muscle proteolytic activity were continued. A quantitative method for the determination of a proteolytic enzyme in beef muscle optimally active at pH 9.0 was developed. An enzyme preparation having a seventeen-fold increase in specific activity was obtained. The proteolytic activity of five muscles from each of five beef carcasses was determined. Tenderization of beef muscle occurs more slowly than tenderization of chicken muscle. This may be due to the fact that chicken muscle had 2- to 3-fold more proteolytic activity.

A tracer study has been started, in cooperation with the Radiological Laboratories of Johns Hopkins Medical Institutes to test the hypothesis that uptake of radioactive strontium by the growing portion of a bone (the epiphyses) will be more rapid in younger, i.e., faster growing animals, and hence would be a measure of physiological maturity. Prior to applying the technique to beef animals, preliminary experiments in cooperation with our Poultry Investigations group have been performed with a less expensive species with faster maturity (chickens). (MQ 3-62)

3. Palatability of Ovines. Under cooperative agreement with the Texas A&M University, research will be initiated to study, identify and evaluate the relationships of chronological age, physiological maturity and carcass quality factors which are considered important in the palatability of lamb and mutton. (MQ 3-34)

B. Quality Maintenance in Handling, Packaging, Storage and Transportation.

1. European Fresh Beef Shipments. Research on the techniques of shipping beef to European markets has been conducted in cooperation with the Transportation and Facilities Research Division, Agricultural Research Service. A test of a forty-foot refrigerated van container to transport fresh hanging beef from Texas to Germany was conducted. German meat inspection regulations require that either the whole head or the lower jawbone, including the masticatory muscles, for each fresh beef carcass

accompany the meat shipment. After 18 days in transit, the beef carcasses showed some areas of dehydration and discoloration; however, the whole heads, which accompanied this shipment, showed considerable bacterial growth which produced a stale, musty odor throughout the load of beef. (MQ 2-75)

2. Lighting Requirements for Evaluation of Meat Quality. A survey of lighting conditions of 56 representative meat packing establishments at four main stations, New York, Kansas City, St. Paul, and Seattle, was completed. Establishments where meat is Federally graded were placed into three classifications: (1) Excellent; (2) Average, and (3) Marginal, based on a subjective appraisal of the lighting conditions by the main station supervisors of the Meat Grading Branch, Consumer and Marketing Service. The average light intensity of these three classifications was 28.75 f. c., 20.97 f. c., and 14.13 f. c., respectively. Quality of light was not as variable. Most establishments used incandescent-type bulbs for sources of light in beef coolers. Fluorescent-type of lighting was found in only a few establishments.

Laboratory tests on the effect of type of light and light intensity upon the evaluation of marbling and color of meat by a panel of expert meat graders have shown little difference in overall acceptability between the type of light when intensity levels are equal. However, low level light intensities (15 foot candles) were judged less acceptable for evaluating marbling and meat color. (MQ 3-59)

3. Effect of Atmospheres of Carbon Dioxide and Nitrogen on Properties of Refrigerated Meats. Studies on the keeping qualities of beef slices held at  $0^{\circ}\text{C.} \pm 0.5^{\circ}\text{C.}$  and 95 percent  $\pm 2$  percent relative humidity with 10, 20, 30, 40, and 100 percent  $\text{CO}_2$  concentrations have been reported. New investigations on the influence of various concentrations of  $\text{N}_2$  have been conducted. It was found that to store beef as long as possible in faultless condition, the least possible initial microbial contamination of the surface was of prime importance. Shelf-life seems to diminish linearly with initial number of microbes. According to organoleptic observations, the keeping time of the control meat was 12 days in all test series and that of test meat was 26 days (10 percent  $\text{CO}_2$ ), 33 days (20 percent  $\text{CO}_2$ ), 27 days (30 percent  $\text{CO}_2$ ), 40 days (40 percent  $\text{CO}_2$ ), and 49 days (100 percent  $\text{CO}_2$ ). (E8-AMS-5(a))

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#### Quality Maintenance in Storage

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## AREA 6

## OILSEEDS AND PEANUTS - MARKET QUALITY

Problem. Harvested oilseeds and peanuts are subject to deterioration in quality and loss in value through fungus attack and contamination, development of mycotoxins, normal metabolic changes, and instability of their oil constituents to atmospheric oxygen. To maintain the quality, more precise information is needed on the biology, ecology, and control of fungi that attack oilseeds and peanuts; and on the physical and chemical changes and the environmental factors which influence these changes during handling, storage, transportation, and processing. Recent problems with aflatoxin suggest the desirability of a complete re-evaluation of handling and storage methods for farmers stock peanuts. Attention should be given to developing new procedures that would avoid the problems associated with fungi and pesticide residues. Also, to insure uniform and standardized products in the marketing channels, new and improved methods and techniques for measuring quality factors need to be developed for use in inspection, grading, and standardization operations.

Peanut flavor is subject to deterioration through improper aeration, drying, handling, and storing. Earlier studies conducted on the effect of artificial drying on peanut flavor and quality were not conclusive. In addition, studies on shelling of farmers stock peanuts have been initiated and there is need to determine the effect of variables in the drying and shelling operations.

## USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving engineers and chemists engaged in basic and applied research on the quality evaluation, quality maintenance, and development of objective methods of quality evaluation of peanuts, soybeans, and other oilseeds. Research on soybeans is conducted at Washington, D. C., research on peanuts is done at Albany, Georgia, College Station, Texas, and Raleigh, North Carolina, in cooperation with the Texas Agricultural Experiment Station and North Carolina State University.

A P.L. 480 grant with the Vallabhbhai Patel Chest Institute, University of Delhi, India, provides for a study of physiological and biochemical factors involved in the production of aflatoxin by Aspergillus flavus. The project runs from 1965 to 1968 and involves \$81,921.52 equivalent in Indian rupees.

A P.L. 480 grant with the Hebrew University in Israel provides for a study of the biology of the fungus Aspergillus flavus Link and its infectivity to plants and harmfulness to animals. The project (Line Project A10-CR-46) runs from 1963 to 1968 and involves \$129,250 equivalent in Israeli pounds.

The Federal effort devoted to research in this program totals 4.7 scientific man-years.

The Department also has a continuing program at Tifton and Savannah, Georgia, involving entomologists and chemists engaged in basic and applied research on problems of insect infestation, damage, and contamination, and of pesticide residues in peanuts in the marketing channels. The research is conducted in cooperation with the Georgia Agricultural Experiment Stations, the Agricultural Stabilization and Conservation Services, the Transportation and Facilities Research Division, the Field Crops and Animal Products Research Branch, growers' cooperative associations, and various industry groups.

The Federal effort devoted to research on prevention of insect infestation was 2 scientist man-years during the reporting period. Much of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the insect problems in stored peanuts.

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 4 scientist man-years is devoted to this area of research.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Objective measurement and evaluation of quality

1. Equipment for Grading Farmers Stock Peanuts. A device to automatically control the rate-of-feed of the pneumatic sampler probe into loads of farmers stock peanuts has been designed and tested. The tests were conducted on Virginia-type peanuts loaded out of a storage warehouse. Results of the tests indicate that within reasonable limits the rate of feed into loads of farmers stock peanuts does not have a significant effect on the amount of shelled kernels caused by sampling.

Extensive field tests on a cleanout device which prevents peanuts from wedging between the inner and outer tube of the pneumatic sampling probe have been completed. The device performed satisfactorily and was installed on all pneumatic samplers for the 1966 marketing season.

A machine has been designed to comminute large samples of peanut kernels, screen the material through a 1/8" perforated screen and draw a representative subsample for aflatoxin analyses in one operation. The machine will handle about three pounds of kernels per minute without limit to size of sample. The subsamples are 1/10 or 1/20 the original sample size. The machine is small and easily cleaned between samples. Further tests are necessary to determine the accuracy of the subsampler. The machine will make it possible to subsample large samples of peanuts at shelling plants so that only small subsamples will need to be sent to laboratories for aflatoxin analysis. (MQ 3-29)

2. Maturity and Damage Factors in Peanuts. Alcohol dehydrogenase, one of the enzymes thought to be responsible for high-temperature off-flavor, has been isolated from peanut kernels and highly purified. Its kinetic properties were similar to yeast alcohol dehydrogenase. Free boundary electrophoresis and cellulose acetate electrophoresis measurements confirm its high state of purity.

A study of carotenoid pigments in peanut oil has shown that beta carotene and lutein are the major carotenoid pigments responsible for the color of oil from immature peanuts and that oil from mature peanuts has no carotenoid pigments present in amounts down to the nanogram per liter range. Almost complete disappearance of the carotenoid pigments during the maturation process of peanut kernels is thus indicated.

Measurements of the light transmittance of oil expressed from peanuts have been made at 425 mu, 455 mu, and 480 mu wavelengths. The study has shown a correlation between light transmittance of the oil, maturity and some curing treatments. "Ripening" caused by removing vines several days prior to harvesting peanuts from the soil also had an effect on light transmittance. Maturity, curing treatment and pre-harvest removal of vines had significant effects on peanut flavor. The results confirm other studies which indicate that oil color determinations may be useful as objective measurements of peanut quality. Another method for estimating maturity in peanuts was tested. This method is based on the measurement of moisture distribution in peanut kernels. Results showed that the surface moisture of the peanut kernel increases in relation to the total moisture as the peanuts become more mature. (MQ 3-88)

3. Distinguishing Soybean Particles from Foreign Matter. Further studies were made to develop a rapid method for separating soybean particles from foreign material that passes through an 8/64" grading screen. A multistage zig-zag air column separator developed by the Stanford Research Institute removed all of the light foreign material and heavy weed seeds leaving a

concentrated fraction of soybean particles containing a large amount of weed seeds. Use of knurled steel rollers to imbed the soybean particles and lift them out of the weed seeds did not prove to be successful. The possibility of measuring the oil content of the mixture of soybean particles and weed seeds as an index of soybean content of the concentrated fraction is not feasible as it is slower than handpicking the samples. Further work has been suspended pending the outcome of a standardization study by the Grain Division, C&MS, using 5/64 and 8/64 sieves. (MQ 3-24)

4. Rapid Detection of Molds and/or Fungal Metabolites in Peanuts. A new method for the rapid detection of aflatoxin in peanuts was developed. This method is based on milli-column chromatography. A sample of peanuts can be tested in 12 to 15 minutes but a number of samples can be run at the same time. The method is inexpensive and simple in operation. Some degree of quantification is possible by making up standard tubes for comparing with samples. Sensitivity is about 5 to 10 ppb.

The relationship between fat acidity and aflatoxin has been studied in large-seeded Virginia-type peanuts. Fat acidity increased quadratically with increased growth of Aspergillus flavus and was highly correlated ( $R = 0.92$ ) with visible fungal growth. Under the test conditions, fat acidity increased from normal levels of 22 mg KOH to 60 mg KOH per 100 g kernels before aflatoxin became detectable. This relationship suggests the use of a rapid method for determining fat acidity to screen samples of peanuts for the possible presence of aflatoxin.

A rapid method for determining fat acidity in grains was tested on peanuts and found to be in good agreement with the AOAC method. Fat acidity of a sample of peanuts can be determined in about 10 minutes by the rapid method. (MQ 3-66(Rev.))

## B. Quality maintenance in handling, drying and storage

1. Storage and Aflatoxin Development in Peanuts. Studies of aflatoxin production in peanuts during commercial storage show that many loads of peanuts going into Segregation I storage contain high levels of aflatoxin. Damaged kernels, loose-shelled kernels and other kernels contained high levels of aflatoxin while sound mature kernels had low amounts. Preliminary results indicate that very little increase in aflatoxin level occurred during storage. (MQ 2-103)

2. Development and Control of Mycotoxins in Virginia-Type Peanuts. Production of aflatoxin in peanuts inoculated immediately after digging with a toxin-producing strain of Aspergillus flavus was studied during windrow harvesting and bulk curing treatments in cooperative studies with

North Carolina State College. Results indicate that, under North Carolina weather conditions, recommended windrow harvesting treatments and bulk curing methods prevent contamination of peanuts in the hull. In some curing treatments peanuts that were shelled during the harvesting operation (loose shelled kernels) became contaminated with aflatoxin.

Two-phase drying was tested as a means of preventing aflatoxin production in peanuts having an initial growth of Aspergillus flavus at the start of the bulk curing process. In the initial phase, elevated drying temperatures up to 150° F. were used to rapidly dry the hulls to arrest further mold growth. The final phase consisted of drying the kernels slowly at less than 95° F. in order to preserve the flavor and milling quality of the peanuts. The results indicate that the hulls can be rapidly dried to less than 20 percent moisture without affecting the flavor or milling quality of the peanuts. However, the two-phase drying treatments used were not effective in preventing contamination of the peanuts with aflatoxin. Much higher levels of aflatoxin were found in loose-shelled kernels than in other peanuts.

The effect of atmospheric composition on the growth of Aspergillus flavus in high moisture peanut kernels has been studied. Treatments included the following atmospheres: 100 percent oxygen; 100 percent nitrogen; 100 percent carbon dioxide; 1 percent to 10 percent oxygen in nitrogen and 65, 75, and 85 percent carbon dioxide in air. The 100 percent nitrogen and 100 percent carbon dioxide treatments prevented spore germination and growth of A. flavus. Low levels of oxygen in nitrogen retarded mold growth to some degree but high levels of carbon dioxide in air were most effective in limiting mold growth. Results indicate that atmospheres of 85 percent carbon dioxide in air would be highly effective in limiting mold growth and aflatoxin production in high moisture peanuts. (MQ 2-103)

3. Development and Control of Mycotoxins in Spanish Peanuts. A test of aflatoxin production on sterile shelled peanuts indicated that all 11 varieties included in the test were effective substrates for the production of aflatoxin.

Extensive tests of the effect of temperature on aflatoxin production in peanuts have shown that in the range of 20 to 35° C. (60 to 95° F.) increasing temperature is inversely related to the time required for significant concentrations of aflatoxins to be produced and accumulated. Above 35° C. (95° F.) toxin production and accumulation declines rapidly until at 40° C. (104° F.) little or no aflatoxin is accumulated although the fungus appears to make a vigorous growth. Furthermore, a diurnal

temperature cycle of 12 hours at 20° C. (60° F.) and 12 hours at 40° C. (104° F.) decreases toxin production and accumulation to about one-tenth of that produced at a constant temperature of 30° C. (86° F.). The incubation temperature also affects the proportional accumulation of the four principal aflatoxins. Aflatoxin B tends to increase in concentration in respect to that of G as the temperature increases. (MQ 2-103)

In a Crops Research Division P.L. 480 project, Aspergillus niger was found to be the most common fungus on peanuts in Israel. The quantity of A. flavus in the kernel mycoflora was found to be relatively small but it increased during storage and during shelling. A. flavus was found in peanut soils at all locations that were investigated. Tests showed that 71.2 percent of the A. flavus isolates from peanut were toxic while 91.1 percent of the isolates from soil were toxic. The introduction of A. flavus to soil had no adverse effect on peanut plants grown therein. The fungus continued to survive in the soil after five months.

4. Development and Control of Mycotoxins in Runner Peanuts. A survey to determine the extent to which peanuts are contaminated by aflatoxin during harvest in the Albany, Georgia, area showed no significant aflatoxin contamination after four days of windrowing. Preliminary information indicated that the major part of the contamination occurred during the period between picking and drying. Many farmers store their peanuts in trailers or elsewhere for period of up to 48 hours before having them dried. Such conditions afford a favorable environment for the elaboration of aflatoxin. (MQ 2-103)

5. Quality of Peanuts in Relation to Drying. Taste panel evaluations of the three most widely grown varieties of peanuts (Spanish, Runner and Virginia) dried in three types of experimental dryers indicated that, in bin dryers, air temperatures of 125° F. when alternated with ambient air every 60 minutes may be used without causing off-flavor or flavor-differences. It was found that peanuts with high initial moisture (45 percent) have an off-flavor when dried with infrared heat by exposing for four-minute periods and alternating with ambient air cooling. Shorter exposure periods have no significant effect on flavor. With a belt dryer, it was also found that flavor differences will result when high moisture peanuts are dried by exposing to an air temperature of 130° F. for 60 minutes, alternated with 60 minute exposures of ambient air. Shorter exposure periods with lower temperatures apparently have no significant effect on flavor. No significant flavor change was found in peanuts dried on the belt dryer from an initial moisture content of 20-25 percent even at a drying air temperature of 145° F. Skin slippage tests on Spanish, Runner and Virginia peanuts showed that peanuts mechanically dried from a high initial moisture content (45 percent) have an abnormally high skin slippage. Spanish peanuts have a higher skin slippage than the other two types when

all are dried under the same conditions. Drying air temperatures of 115° F. and above cause a significantly higher skin slippage than peanuts dried with air. Drying temperature of 130° F. caused no further increase and a temperature of 145° F. increased skin slippage only slightly. (MQ 2-107)

6. Physiological and Biochemical Factors Involved in the Production of Aflatoxin by *Aspergillus flavus*. Preliminary investigations have dealt with the determination of the various growth conditions of *Aspergillus flavus* and estimation of different metabolic products, such as carbohydrates, proteins, kojic acid and alpha keboacids on a standard growth medium. The presence of enzymes of the citric acid cycle were demonstrated for the first time in *Aspergillus flavus*. (A7-MQ-7)

7. Natural Antioxidants in Vegetable Oil Storage. After adaptation of the falling film molecular still to its use as a deodorizer, approximately 400 samples of refined and crude cottonseed, soybean, corn and safflower oils have been deodorized to simulate methods used in commercial practice. The presence of primary and secondary oxidation products in the oils after heat treatment and before deodorization are confirmed by peroxide values after deodorization. Further laboratory tests are to be made on the deodorized oil now held frozen. (MQ 3-25)

8. Vegetable Oil Storage. The effect of metals and light upon olive, peanut and soybean oils in storage from 800 to 900 days indicated the following: None of the crude peanut and olive oils in contact with metals (copper, iron, zinc, tin stainless steel) reached a peroxide value of 100. Refined soybean and olive oils, after about 800 days, exceeded this value. (E15-AMS-12)

9. Effects of Storage Temperatures on Quality of Vegetable Salad Oils. Cottonseed and soybean salad oils in one-gallon sealed containers have been under heat treatment for periods up to 18 months. Flavor panel evaluations at the end of 6, and at the end of 12 months, show that three soybean salad oils held at temperatures of 90°, 100°, and 110° F. for periods up to 12 months have developed off-flavors significantly different from the control oils (which have been held frozen). Three cottonseed salad oils held at these same temperatures up to the end of 12 months show slight deterioration in flavor, which is not as yet significantly different from the frozen control oils. (MQ 2-106)

10. Estimating Stinkbug Damage in Soybeans. Soybeans damaged by stinkbugs show an increase variation in the moisture contents of individual seeds. Determination of the range of moisture contents in a sample of soybeans may give a means of detecting, and of estimating the extent of stinkbug damage. No compound, which could be readily determined, has been found in damaged beans which is not present in undamaged beans. (MQ 3-65)

### C. Prevention of insect infestation

1. Biological and Physical Control. Intermediate-scale experiments showed that 4 inert dusts applied at 3 rates on farmers stock peanuts were not as effective as the standard malathion treatment after 9 and 12 months of storage. Under conditions of this test, the breakdown of effectiveness of the inert dusts occurred between the 6th and 9th months of storage.

(MQ 1-27(Rev.))

The almond moth was the most prevalent insect in peanut shelling plants as determined by "blacklight" suction-type traps. The red flour beetle was the beetle captured in greatest numbers. Lesser numbers of 15 other common stored-product insects were captured by the traps. The greatest numbers of insects were taken during the warmer summer months after the shelling plants had closed down for the summer.

(MQ 1-12)

Light trap tests in peanut warehouses showed that Indian-meal moths gave the greatest positive response to green light. Cigarette beetles and lesser grain borers responded in greater numbers to traps with ultraviolet sources. Light traps suspended horizontally in peanut warehouses captured greater numbers of adult moths than did traps suspended vertically.

(MQ 1-12)

Indian-meal moth larvae from a corn mill were found infected with a crystal-forming bacterium resembling Bacillus thuringiensis. Indian-meal moth larvae from peanut warehouses were found infected with a granulosis virus, only recently found in this moth in California. This is the first known appearance in peanut warehouses. Almond moth larvae from peanut warehouses were found infected with a polyhedrosis virus, the first known report from this species. Both viruses were highly infectious in laboratory feeding studies. The polyhedrosis virus was more host specific than was the granulosis virus.

(Exploratory)

All red flour beetle adults in shelled and inshell peanuts stored in hermetically sealed 1-gallon bottles at 40°, 80°, and 100° F. were dead within 4 weeks. Trogoderma glabrum and rice weevil adults were exposed 3 and 7 days and T. glabrum larvae 7 and 14 days at 40°, 60°, 80°, and 100° F. to binary and ternary mixtures of nitrogen, oxygen, and carbon dioxide. All of the insects were killed within 7 days at 80° F. when exposed to the binary mixtures containing 0.5 percent or less of oxygen or to ternary mixtures containing 2 percent or less of oxygen and 93 percent or more of carbon dioxide. The T. glabrum and rice weevil adults were also killed within 3 days when the oxygen concentration was 13.5 percent or less and the carbon dioxide concentration 47.5 percent or more. One-day-old Indian-meal moth eggs were exposed for 7 and 14 days at 80° F. to binary and ternary mixtures

of oxygen, nitrogen, and carbon dioxide. With the exception of the binary mixtures consisting of 10.5 percent of oxygen and 89.5 percent of nitrogen, two-thirds or more of the eggs were dead within 2 days after a 1-week exposure. Maximum mortality occurred in mixtures with 2.7 percent of oxygen or less. (MQ 1-12)

Trogoderma glabrum larvae were exposed 2, 4, and 7 days in wheat in towers purged with nitrogen and carbon dioxide. At 100 and 200 cc./min. nitrogen and carbon dioxide reduced the oxygen concentration to about 1 percent in 1 day. At the higher purging rate, carbon dioxide killed 98 percent of the larvae within 4 days, while nitrogen killed only 65 percent within 7 days. At 100 and 50 cc./min. carbon dioxide killed 100 and 89 percent of the larvae, respectively, within 7 days. Red flour beetle adults were exposed to nitrogen and carbon dioxide purging for 6 and 24 hours in towers containing shelled and inshell peanuts. An average of less than 2-percent mortality occurred among the insects exposed for 6 hours only. Carbon dioxide purging for 24 hours at 100 and 200 cc./min. killed an average of 47 and 81.5 percent of the insects, respectively, in the inshell peanuts. However, a mortality of only 22 and 60 percent of the insects, respectively, occurred in the shelled peanuts. Nitrogen at 200 cc./min. killed only about 7.5 percent of the insects in inshell peanuts, while about 60 percent of the insects in the shelled peanuts were dead. (MQ 1-12)

2. Improved Pesticidal Control. Diazinon and fenthion at application rates up to 20 p.p.m. were not as effective as the standard malathion treatment and were not at all effective after 6 months, in small-bin intermediate scale tests with farmers stock peanuts. After 9 months of storage the peanuts originally treated with 20 p.p.m. of diazinon contained less than 1 p.p.m. of deposit. (MQ 1-27(Rev.))

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

##### Objective Measurements and Evaluation of Quality

- Schroeder, H. W., and L. J. Ashworth, Jr. 1966. Aflatoxins: Some factors affecting production and location of toxins in Aspergillus flavus-oryzae. Journal of Stored Products Research. 1:267-271. (MQ 2-103)
- Pattee, H. E., E. O. Beasley, and J. A. Singleton. 1965. Isolation and identification of volatile components from high-temperature-cured off-flavor peanuts. Journal of Food Science. 30: 338-392, No. 3. (MQ 3-88)
- Velasco, James. 1965. Improved techniques in neutral oil determinations. Journal of the American Oil Chemists' Society. 42: 160, No. 2, February. (MQ 3-45)

Prevention of Insect Infestation

Press, Arthur F., Jr., and Phillip K. Harein. 1965. Mortality of adult red flour beetles, Tribolium castaneum (Herbst), and atmospheric gas concentrations in simulated peanut storages purged with carbon dioxide and nitrogen. Bul. Ent. Soc. Amer. 11(3): 178. (MQ 1-12)

Press, Arthur F., Jr., and Phillip K. Harein. 1966. Mortality of red flour beetle adults and Indian-meal moth larvae in nitrogen and carbon dioxide. Jour. Ga. Ent. Soc. 1(2): 15-17. (MQ 1-12)

PUBLICATIONS -- STATE EXPERIMENT STATIONS  
and COOPERATIVE PROGRAMS

A. Objective Measurement and Evaluation of Quality

Pomeranz, Y. 1965. Evaluation of factors affecting the determination of nitrogen in soya products by the biuret and orange-G dye-binding methods. J. Food Sci. 30(2), pp. 307-311. (Kans.)

Young, Clyde T., and Holley, K. T. 1965. Comparison of peanut varieties in storage and roasting. Ga. Agr. Exp. Sta. Tech. Bul. (n.s.) 41. (Ga.)

## AREA 7

## COTTON AND COTTONSEED - MARKET QUALITY

Problem. Technological advancement in production, harvesting, and ginning of cotton brought on by mechanization has resulted in changes in the quality of cotton fiber which are not recognized by present methods of quality evaluation. Mill operators, both domestic and foreign, have reported that these changes have reduced the spinning quality of cotton, thus increasing processing costs and lowering the value of finished products. Precise information is needed on the processing performance and manufactured product quality of cottons which have been subjected to various production, harvesting and ginning practices in preparation for market. New and improved techniques, devices, and procedures for measuring quality factors of cotton fiber are needed to provide better grading and standardization of lint cotton, and indicate the true processing performance and manufactured product quality.

Cottonseed is subject to deterioration in quality and loss in value through fungus damage and contamination, normal metabolic changes, and instability of its oil constituents when exposed to the atmosphere. To maintain its quality, more precise information is needed on the environmental factors which influence these changes during handling, storage, transportation, and processing. Also, to insure uniform and standardized products in the marketing channels, new and improved methods for measuring quality factors need to be developed for use in inspection, grading, and standardization programs.

## USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving textile engineers, cotton technologists, chemists, and engineers in basic and applied research on objective measurement and evaluation of quality of cotton fiber and on the quality evaluation and quality maintenance of cottonseed. The research is conducted at Washington, D. C., Lubbock, Texas, Auburn, Alabama, and at Clemson, South Carolina, in cooperation with Clemson University, and by research contracts with Clemson University, Texas Technological College and Auburn University.

The program includes the following foreign projects under PL 480: A grant to Centre de Recherches des Industries, Rouen, France, provides for an investigation of fiber maturity and breakage during mechanical processing of cotton, and the relation of these factors to processing performance and product quality. Its duration is four years, 1962-1966, and involves PL 480 funds of \$63,202 equivalent to French francs.

A grant to the Fiber Research Institute, T. N. O., Delft, Holland, provides for a study of the influence of length properties on the mill processing performance of cotton. Its duration is four years, 1962-1966, and involves PL 480 funds with a \$77,781 equivalent in Dutch guilders.

The Federal scientific effort devoted to research in this area totals 21.8 scientific professional man-years subdivided as follows: cotton, 13.1, with 6.1 under research contract, and cottonseed, 2.6.

Projects terminated during this period included evaluation of cotton fiber measures and their effects on fiber properties of yarn strength and appearance (MQ 3-17), and instrument for homogenizing and orienting fibers in samples for cotton testing. (E9-AMS-5(a))

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 4 scientist man-years is devoted to this area of research.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Objective Measurements and Evaluation of Quality of Cotton

1. Effect of Various Production, Harvesting, and Ginning Practices on Cotton Quality and Spinning Performance. Research studies are underway at the Cotton Quality Spinning Laboratory to determine (1) the effect on fiber properties, spinning performance and product quality of (a) storage humidity, (b) ginning treatments, (c) rate of production, (d) spindle picking and stripper harvesting of cotton, (e) gleaning of cotton, (f) use of reclaimed cotton, and (g) different micronaire and different grades of cotton. Results obtained thus are summarized below:

(a) 1964 Foreign Matter Study. This study is a continuation of the 1963 study to determine the effects of foreign matter on spinning performance, product quality, and cost of raw cotton. Extreme gin cleaning conditions were used in the 1964 study and the test results showed that the cotton which received the least amount of cleaning produced the highest break factor, the most uniform yarn, and the lowest level of spinning end breakage when card crusher rolls were used. These results indicate that the amount of cleaning during ginning should be greatly reduced and that certain revision are needed in our present marketing system. A progress report on this work has been published.

(b) 1964 California Fiber Properties Study. This study was designed to determine the spinning performance and yarn quality of California cottons differing in certain fiber properties. It was performed under contract by Texas Technological College and preliminary analyses of results indicate that Acala 4-42 cotton has better spinning characteristics than the other cottons tested. A report is being prepared for this study.

(c) 1965 Pima Ginning and Crusher Roll Study. This study was made to determine the effects of ginning treatments and crusher rolls on spinning performance and product quality of combed Pima cotton. Preliminary analysis of results indicate that card crusher rolls were more effective than the gin cleaning conditions used in reducing spinning end breakage. A report is being prepared for this study.

(d) 1965 Foreign Matter Study. This study is a continuation of those made in 1963 and 1964. Preliminary analysis of the 1965 test indicate the findings parallel those of previous years dealing with the effects of trash on spinning performance and product quality. The results of this three-year study indicate that less emphasis should be placed upon trash removal during ginning. A report is being prepared for this study.

(e) 1965 Color and Trash Study. This study was made to determine the effect of varying color levels caused by field weathering in combination with varying foreign matter levels in ginned lint, on spinning performance and product quality. Preliminary analysis of results showed that the cotton changed one grade in color during seven weeks of exposure and this color change did not affect spinning performance. The data are being further analyzed and a report will be prepared. (MQ 3-33)

2. Chemical Residues on Surface of Cotton Fibers. Improved techniques are being developed to characterize the chemical nature of the cotton fiber surface in reference to chemical residues and inherent chemical composition that may effect spinning performance. Quantitative determination of waxes, sugars, and other extractables was not useful in predicting the tendency of some cottons to stick and lap on rolls, except when the fibers contain abnormally high amounts of these substances. Tests of a more qualitative nature on these cottons have given promising results. A residue which accumulated at the crusher rolls on the cards was shown by infrared analysis to be crushed cottonseed meat and cottonseed oil and not normal cotton wax. In another instance, hydrocarbon contamination (lubricating oil) was detected by observation with ultraviolet light and was measured quantitatively with a fluorometer. The hydrocarbon contamination was also shown by extraction with cold hexane. (MQ 3-42)

3. Frictional Properties of Cotton Fibers. Drafting force variability measurements have shown that fiber length variability explained nearly all of the drafting irregularity in a wide selection of card sliver samples from the Pilot Plant spinning studies. The instrumentation and techniques developed to measure drafting irregularity of sliver have proven to be practical for measuring drafting efficiency directly in the drafting process. To study the spinning operation, a cohesion tester, incorporating a conventional spinning drafting system, has been designed and built. This new tester is being used to measure the effects of drafting mechanism adjustments

on drafting force and drafting force variability as affected by certain fiber properties (length, length variability and fineness). The ultimate purpose of this work is to determine optimum drafting efficiency for maximum spinning utility. (MQ 3-43)

4. Instrument Evaluation. The use of filters to eliminate the effect of background color on the level of the trash measurements was unsuccessful.

Evaluation of the Stanford Research Institute's prototype cotton fiber blender clearly indicated that the instrument was inefficient in blending a sample of cotton lint and caused tremendous neppiness of the fiber.

A production fibrograph and a new fibrosampler were evaluated during the year. Measurement of one beard, as one observation, on the production fibrograph gave results equal to those of two beards measured as one observation on the Digital Fibrograph. The production fibrograph can make 50 percent more observations per hour (120) than can the Digital Fibrograph (80) and it requires only one-half the number of beards for measurements.

Two additional instruments have been received for evaluation: (1) an automatic cotton fiber strength tester developed by Stanford Research Institute, and (2) a length analyzer developed by Motion Control, Inc. Work is just beginning on these two instruments. (MQ 3-47)

5. Instrument and Techniques for Rapid Determination of Cotton Fiber Strength. This project is under a contract with Motion Control, Inc., Dallas, Texas. Phase I, covering the development of a specimen system which prepares a test beard and measures a pre-selected cross-sectional area at which the fiber beard will be clamped in the jaws of a breaking device. In this way, all test specimens can be broken at a constant cross-sectional area independent of the amount of cotton in the test specimen. This phase is near completion. (MQ 3-71(C))

6. Methodology Studies for Development of Spinning Performance Tests. These studies are designed to develop scientific spinning procedures based on lint quality factors and include development of appropriate instrumentation. Results so far obtained are given below:

(a) Development of an Instrument for Rapid Determination of Cotton Color and of Trash Content Separately in a Sample of Cotton. A contract was negotiated with Outlook Engineering Corporation, Alexandria, Virginia on this problem. The first two phases of the work on this contract have been completed. Phase I involved the development of a scanner and Phase II involved the development of trash-meter circuits to incorporate the scanner developed in Phase I. (MQ 3-81(C))

(b) Relationship of Fiber Maturity to Fiber Breakage During Mechanical Processing. During the past year, two additional varieties of cottons of six bales each representing six levels of maturity (micronaire readings) were investigated. The results obtained were similar to those obtained on

the six bales of Acala 4-42 cottons reported last year. Fiber breaking at reversals in the fibrillar structure and fiber breakage during processing is much greater in the mature than in the immature cottons. A report covering the work of this contract is being prepared. Upon receipt and acceptance of this report, this project will be terminated. (E9-AMS-4(a))

(c) Instrument for Homogenizing Test Sample. Several devices were designed, modified and built using electrostatic, pneumatic and mechanical means for performing the three necessary operations - opening, paralleling, and homogenizing, but none were entirely successful. The investigations showed (1) the use of electrostatic fields alone and in combination with pneumatic means did not produce sufficient forces to allow stock opening or fiber parallelization; (2) the use of drums or cylinders covered with metal wire clothing insuring good opening of the material resulted in excessive fiber breakage; (3) the use of carding brushes and aprons produced numerous neps in the test sample and resulted in insufficient opening and parallelization of fibers; (4) the use of drums or cylinders covered with abrasive matter (emery cloth) allowed a very satisfactory opening of the stock, provided the stock is fed very thin and used in conjunction with pneumatic means for transporting the opened fibers, and (5) it was very difficult to carry out the three basic operations (opening, parallelization, homogenization) necessary to rapid preparation of fiber test samples in one continuous cycle. This grant has been terminated. (E9-AMS-5(a))

(d) Influence of Fiber Length Distribution on Mill Processing. The Delta-pine cotton showed the same trends as those found for the Acala cotton in that yarn breaks which can be ascribed to yarn itself, during weaving are highly related to the number of weak spots in the yarn. More than one-half of the total yarn breaks were caused by loosening of knots. A report covering all phases of this project is being prepared. (E19-AMS-8(a))

## B. Objective Measurement of Quality of Cottonseed

1. Method for the Rapid Measurement of the Refining Loss of Cottonseed Oil in Small Lots of Seed. Our new chromatographic method for determining the neutral oil content in crude vegetable oils was subjected to a collaborative test with seventy-one vegetable oil laboratories participating. Results indicated that the new method was considerably more accurate than the method in use. It is now being adopted by the AOCS and by the National Soybean Processors Association for use in grading soybean oil. (MQ 3-45)

2. Re-evaluation and Improvement of Official Cottonseed Standards. The pneumatic cottonseed sampler (basic model developed in this Branch) was used at oil mills for the second season. Approximately one-half of the cottonseed processed was sampled by this new sampler. A study of the optimum sample size and largest lot of cottonseed which may be accurately represented by a sample was defined for initiation at the beginning of the harvest season.

Price relationships during the past year of cottonseed and oil, meal, hulls, and linters showed that the present factors now in use continued to satisfactorily reflect the value of the seed and products. (MQ 3-51)

3. Molds and Aflatoxins in Cottonseed. The first full year survey of the presence of aflatoxins in cottonseed being processed and meal produced at 54 oil mills was completed. Nine out of ten cottonseed samples were free of aflatoxins as compared with three out of four meal samples. Although fewer seed samples were free of aflatoxins in 1965-1966, a smaller number of samples contained sizeable amounts of aflatoxins. Areas in which aflatoxins were found in considerable amounts in 1964-1965 were found to be relatively free until March 1966. Some areas in which few samples with aflatoxins were found in 1964-1965 were found to have a larger number of samples with mycotoxins the following year.

The problem of sampling cottonseed was indicated by a study of the aflatoxin content of 150 randomly selected single seeds in a lot of field damaged cottonseed which assayed 800 parts per billion. Eighty-five percent of these seeds had no detectable aflatoxins. One seed assayed 600,000 parts per billion with the remaining 17 showing from 70 to 49,000 parts per billion.

A simple ultraviolet light test was developed for distinguishing uncontaminated seed. Nine out of ten samples could be accurately identified when questionable seed were omitted. When the latter were counted as positive, eight out of ten were correctly graded. (MQ 2-108)

#### C. Quality Maintenance in Handling and Storage

1. Molds and Aflatoxin in Cottonseed. Significant concentrations of aflatoxins developed in seed cotton after ten days storage in a cooperative test with TAES agricultural engineers. Picking cotton wet with dew, picking from non-defoliated plants, and increasing the density during storage caused an increase in the amount of aflatoxin produced in the seed and decreased the storage time that the seed remained toxin free.

In a cooperative test with the Southwestern Ginning Laboratory, 148 samples of cottonseed from five gins in the southwest were assayed for aflatoxins. Toxins were detected in 95 of the samples in concentrations ranging from a trace to 645 ppb. There was no significant correlation between toxin concentration and percentage of gin damaged seeds per sample. No differences between aflatoxin production in roller or sawtoothed ginned cottonseed during storage were noted. Non-dehulled acid-delinted seed were assayed for aflatoxins B<sub>1</sub> and B<sub>2</sub> without a loss of accuracy. In vitro time/temperature studies with acid-delinted cottonseed indicate that maximum aflatoxin production occurred at slightly higher temperatures than was found with shelled peanut or rough rice. (MQ 2-115)

2. Molds and Aflatoxins in Cottonseed. Cottonseeds inoculated with spores of Aspergillus flavus, and rinsed for one minute in 3 percent hydrogen peroxide, 1 percent sodium hypochlorite, 5 percent formaldehyde, or 2 percent peracetic acid, without a subsequent water rinse, were completely free of A. flavus, as shown by plating-out the seeds on agar. Also, a 15-second dip in 70 percent ethyl alcohol gave the same result. (MQ 2-108)

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

### Objective Measurements and Evaluation of Quality

Mangialardi, Gino J., Jr., A. Clyde Griffin, and Edward H. Shanklin. 1965. Moisture restoration to cotton at the gin: Effects on fiber and spinning properties. MRR No. 708, USDA-ARS, August. (MQ 3-33)

Newton, Franklin E., Preston E. LaFerney, and Samuel T. Burley, Jr. 1965. Effects of fineness, length uniformity and card crusher rolls on spinning performance and yarn properties. Paper presented at the Research and Testing Clinic, Auburn University, Auburn, Alabama, August, and published in Textile World, pp. 80-83, March 1966. (MQ 3-33)

Carpenter, Frances, and Edward H. Shanklin. 1965. Fibrosampler evaluation: Specimen preparation of raw and processed cotton and comparisons with other techniques. Paper presented at the TQCA Meeting, Winston-Salem, North Carolina, September, and published in Textile Bulletin, pp. 33-37, January 1966. (MQ 3-47)

Stedronsky, V. L., John E. Ross, and Edward H. Shanklin. 1965. Drying and cleaning cotton at the gin: Effect on fiber properties and spinning performance, San Joaquin Valley, 1959-1960. MRR No. 710 - USDA-ERS-ARS, December. (MQ 3-33)

Williamson, E. Buford, Charles S. Shaw, Zolon M. Looney, and Edward H. Shanklin. 1966. Comparative effects of mechanical picking spindles and handpicking on cotton quality and spinning performance in Mississippi, 1960-1963. MRR No. 730 - USDA-ERS-ARS, January. (MQ 3-33)

Newton, Franklin E., Samuel T. Burley, Jr., and Vernon P. Moore. 1966. The effect of trash removal on cotton processing performance and product quality. Paper presented at the 1966 Cotton Research Clinic, February 1966, and published in Textile Bulletin, pp. 28-30, 75, March. (MQ 3-33)

Shanklin, Edward H., Konrad Semrau, and Preston E. LaFerney. 1966. Comparative effects of an experimental and conventional seed cotton drying system on cotton fiber properties. MRR No. 733 - USDA-ARS, April. (MQ 3-33)

Graham, John S. 1966. Effects of cotton fiber properties on drafting irregularity. Paper presented at the ATMI Open House, Clemson, South Carolina, May 1966, and published in Textile Industries, pp. 140-142, 228, May. (MQ 3-43)

## AREA 8

## WOOL AND MOHAIR - MARKET QUALITY

Problem. Wool fineness, variability, and color are the most important quality characteristics in determining the grade and consequently the economic value of wool. However, present methods of determining wool fineness and variability are slow and tedious and the causes of yellow coloration of raw wools are not known. Animal fibers in raw or manufactured form are subject to damage by several kinds of fabric insects, estimated to cause at least \$350 million loss annually. Basic research on the physiology and chemistry of wool digestion by insects is needed to provide information that can be used in developing better preventive treatments. The safety of several compounds now used for mothproofing wool has been questioned, and safer effective treatments are needed.

## USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving chemists and engineers in basic and applied research on the quality evaluation and development of objective methods for quality evaluation of raw wool. The research is conducted at Beltsville, Maryland, and under a research contract with the University of Wyoming.

Line Project MQ 3-92(C) covering a study of "the interrelationships of wool fineness, softness, quality and market evaluation of domestic wools" was initiated during this period.

Under a P.L. 480 grant to the Shrim Ram Institute for Industrial Research, Delhi, India, research is underway on the "canary coloration" of raw wools. Its duration is for 5 years, 1963-1968, and involves P.L. 480 funds with a \$92,536 equivalent in rupees.

The Federal effort devoted to research in this area of quality evaluation was 1.0 scientist man-year.

There is also a continuing program headquartered at Savannah, Georgia, involving applied research in entomology and chemistry, directed toward the protection of wool and other animal fibers against insect damage. The research is conducted in cooperation with the Armed Forces Pest Control Board and various industry groups.

A 1½-year contract with the Harris Research Laboratories became effective in June 1965, to study the physical and chemical factors affecting the sorption and retention of quaternary ammonium compounds by wool. Another contract with the same Laboratories, for a 2-year study to develop procedures for applying quaternary ammonium compounds as mothproofing treatments, became effective in June 1966.

The Federal effort devoted to research on the protection of wool against insect damage is 1.7 scientist man-years, of which 0.5 is under research contract. Some of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the insect problems in wool.

#### PROGRAM OF STATE EXPERIMENT STATIONS

A total of 2 scientist man-years is devoted to this area of research.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Objective measurement and evaluation of quality

1. "Canary Yellow" Coloration of Raw Wool. Results on a wide variety of unstained and canary stained fleeces for yolk and pigment content have confirmed the earlier observation that canary coloration is mainly caused by the entry of suint pigments into the fiber whenever the grease content is too low to act as a barrier and that the canary coloration of fleeces was not due to photochemical oxidation of either tyrosine or tryptophan constituents. It was found that prolonged exposure to humid atmosphere was not directly responsible for canary coloration. It has been possible to impart canary color to white wool by staining with pigments extracted from canary colored wools. Also, significant differences have been observed in behavior towards permanent set in canary stained and unstained wools of the same quality. (A7-AMS-12)

2. Sample Preparation of Wool for Fineness Determination by Coulter Counter Technique. Studies on the factors involved in cutting wool fibers uniformly into length of 100 microns have been conducted, including the use of shrinkable plastic tubing for holding the wool fibers, means of supporting and advancing the fiber bundle, angle of the cutting blade and effect of different anvil materials. Results showed that when a tuft of wool is drawn through a short length of shrinkable plastic tubing, then shrunk, the wool fibers become axially aligned, and tightly packed in a bundle which is

convenient to handle. These bundles of fibers are placed in a micrometer advancing jaw and a channeled anvil support to be cut with a razor blade which is mounted at a 6° cutting angle. Using these techniques for cutting, wool samples have produced wool fibers of 100 with a standard deviation of 12. These cut wool samples can then be used to determine wool fineness using the Coulter Counter Technique. (MQ 3-69(C))

## B. Prevention of insect infestation

1. Nontoxic Mothproofing Treatments. Of 29 candidate compounds tested, five were found promising: Shell SD 8211, BAY 45515, BAY 58733, BAY 69047, and BAY 77488. BAY 77488 was found particularly promising because of its extremely low mammalian toxicity, 8,000 to 10,000 mg./kg. oral LD<sub>50</sub> for rats, and its effectiveness at very low concentrations. A calculated deposit of 0.0025 percent by weight of the cloth protected the fabric against damage by the larvae of the black carpet beetle, and a calculated deposit of 0.005 percent satisfactorily protected the cloth after three drycleanings. BAY 77488 produced some yellowing when applied to undyed test fabric but there was no visible staining on dyed cloth. A closely related compound, more stable and less staining, is being investigated. Poly-substituted nitrogen compounds (Polysubs) continue to appear promising after application studies conducted in home-type washing machines. The treatments were very effective although there were indications of uneven distribution of the compound on the cloth. (MQ 1-26)

Studies on the sorption and retention of quaternary ammonium (QA) mothproofing compounds have shown that not all QA compounds are adsorbed at the same rate. In general, (1) increasing the temperature and pH increases add-on, (2) increasing time only slightly increases add-on, and (3) increasing the concentration of the QA in the bath greatly increases add-on but has little effect on the percentage of exhaustion from the bath. (MQ 1-49(C))

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

### Prevention of Insect Infestation

U. S. Dept. of Agr., MQRD. 1966. Protecting woollens against clothes moths and carpet beetles. Home and Garden Bul. No. 113, 8 pp., April. (MQ-1)

## PUBLICATIONS -- STATE EXPERIMENT STATIONS and COOPERATIVE PROGRAMS

Davis, S. P., and J. W. Bassett. 1965. The influence of age on fiber diameter, staple length, and yield of mohair. Tex. Agr. Expt. Sta. PR-2344. (Tex.)

## AREA 9

## POTATOES - MARKET QUALITY

Problem. The increased demand for potatoes to be used for chips, frozen french fries and other processed forms has created special problems of preventing undesirable chemical changes due to low temperatures during storage and transport. The use of higher temperatures has brought on additional problems of moisture loss and of bacterial and fungal decay. Higher temperature storage also calls for control of sprouting, with increased emphasis on sprout inhibitors. Objective indices are needed to identify quality factors that are important for specific product usage and relate measurable characters of the raw product to quality of the processed product. Also needed are instruments for non-destructive detection and rejection of potatoes with internal disorders during grading.

## USDA AND COOPERATIVE PROGRAM

The Department has a long-term program involving horticulturists, plant pathologists and plant physiologists engaged in applied and basic research. The work at East Grand Forks, Minnesota, is conducted in cooperation with the Minnesota and North Dakota Agricultural Experiment Stations and the Red River Valley Potato Growers Association. The work at Presque Isle, Maine, is in cooperation with the Maine Agricultural Experiment Station. Research on transportation of early potatoes for chips is conducted by the Fresno, California, station. The studies at Beltsville involve quality evaluation, sprout inhibitors and basic research. Studies on market diseases are conducted at Chicago and Belle Mead, New Jersey.

The Federal effort devoted to research in this area totals 4.7 scientist man-years. Of this number 0.3 is devoted to quality evaluation; 0.5 to quality maintenance in handling and packaging; 1.5 to quality maintenance in storage; 0.2 to quality maintenance during transportation; 0.2 to post-harvest physiology; and 2.0 to postharvest disease control.

One project was terminated during this period: Loading methods and protective services for Maine potatoes. (MQ 2-42).

## PROGRAM OF STATE EXPERIMENT STATIONS

A total of 8 scientist man-years is devoted to this area of research.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Color Measurement in Potato Chips. Potato chips ranging in color from very light to very dark were measured with 6 different instruments. The same samples were also rated visually using the National Potato Chip Institute standards as a guide. The data suggest that potato chip color can be satisfactorily measured with several instruments and in a variety of forms (whole chips, ground, or pressed cake). Correlation coefficients between visual judgment and spectral reflectance at 546 nm, Hunter Rd or L, and tristimulus values X, Y, and Z were all highly significant and appear promising as a basis for purchase of potatoes for chipping. (Exploratory)

B. Quality maintenance in handling and packaging

1. Stone Separation and Tuber Bruising. Exposure of tubers to water during flume handling had no detrimental effect on the quality for seed. Quality studies were made after transit, storage and in field trials.

A study of the relation of soil temperature, air temperature, and tuber temperature to the resistance of tubers to bruising indicates that soil temperature during harvest may play a more important role in bruising than air temperature. Subjecting tubers to a temperature different from that in storage shifted resistance to bruising-- increased resistance if moved to warmer air; decreased resistance to bruising if moved to air cooler than the tuber. Gradual warming over a 3- to 4-week period increased bruise resistance more than rapid warming. (MQ 2-93)

C. Quality maintenance in storage

1. Storage Temperature on Processing Quality. Decay in potatoes stored 2½ months at 55° F. for chip manufacture ranged from 3 percent with an air-flow rate of 2 cfm/cwt. to 27 percent with gravity airflow (near zero). Internal black spot, however, was nearly four times as extensive at the 2 cfm/cwt. rate as with gravity airflow. Decay and internal black spot at 0.4 cfm/cwt. were intermediate. (MQ 2-69)

2. Periods and Rates of Ventilation on Quality of Maine Potatoes. Forced air ventilation through storage bins at rates of 2.4 and 3.0 cfm/cwt. was effective in drying up frost damaged tubers which had been injured in the field. Potatoes stored at 38° with these rates of air movement did not develop soft rot. The color of french fries from stored tubers was darker as the air circulation time increased. Tubers from bins receiving air circulation 12% of the time fried almost as light as the no-air-circulation control; tubers from bins with air circulation 50% of the time fried darkest with those from bins with air circulation 25% of the time intermediate. (MQ 2-92)

Severe surface mold and slight to severe mahogany browning developed in two lots of Katahdin potatoes stored continuously at 32° for 15 weeks or longer. No mahogany browning and very little mold developed when the storage period at 32° F. was interrupted by 1-week periods at 60° so that the longest continuous time at 32° was 3 weeks. (MQ 2-92)

Fusarium tuber rot, Verticillium-pinkeye rot and soft rot were controlled in potatoes stored at 50° F. by using forced air through-ventilation. Excessive shrinkage from desiccation with subsequent pressure bruising, and internal black spot which developed in previous storage studies was greatly reduced by the use of intermittent rather than continuous ventilation after the initial cooling. (MQ 2-92)

3. Control of Sprouting of Potatoes. Irish Cobbler potatoes treated with CIPC (isopropyl-N-(3-chlorophenyl) carbamate) in dips at concentrations lower than recommended for commercial application (0.5 to 1.0%) developed internal sprouts. The most internal sprouting resulted from treatments with emulsions containing 500 ppm (0.05%). At this concentration external sprout growth was inhibited to about 50%, by weight, of that of untreated tubers. As emulsions more dilute than 500 ppm were used more external sprout growth and fewer internal sprouts were found. As more concentrated emulsions were used both external and internal sprout growth was less.

Scrubbing with a detergent followed by rinsing with a stream of hot water, or washing with a stream of hot water adequately removed residue of CIPC from contaminated wooden pallet boxes. The sprouts formed on the tubers stored in the untreated control boxes were of the rosette type, whereas, the sprouts formed by the tubers stored in the treated boxes were normal and vigorous. Washing with cold water was ineffective. (Exploratory)

#### D. Quality maintenance during transportation

1. Transit Temperature of California Potatoes. When freshly dug Kennebec potatoes were held at simulated transit temperatures in the range of 50° to 70° F., the chip color was lighter as the temperature increased. Tubers held for 9 days at 50° or 55° yielded darker chips than those held for 5 days. However, holding time did not influence chip color when potatoes were held at 60° to 75° F. Potatoes that yielded dark chips after 5 or 9 days at 50° or 55° could not be reconditioned during subsequent holding for 4 days at 75°. Field temperatures that averaged 51° to 58° F. one week before the potato harvest resulted in darker chips than field temperatures of 72° to 81° F. one week before harvest. Time of harvest (May 5 to June 5 vs. June 23 to July 7) did not influence chip color. (MQ 2-55)

2. Low Oxygen Atmospheres. Freshly dug White Rose potatoes were held 8 days at 59° F. to simulate shipment in atmospheres containing  $\frac{1}{2}$ , 1, 5% O<sub>2</sub> or air and 8 additional days in air at about 68°. No benefits from reduced oxygen holding were observed. In lots held in  $\frac{1}{2}$ % O<sub>2</sub>, 14 to 30% of the tubers were decayed (bacterial soft rot) at removal; in those held in 1% O<sub>2</sub> 0 to

14% were decayed, and none decayed in 5% O<sub>2</sub> or air. Surface mold developed extensively in  $\frac{1}{2}$  and 1% O<sub>2</sub>, and only slightly in 5% O<sub>2</sub> or air. Black heart affected 12 to 44% of tubers held in  $\frac{1}{2}$ % O<sub>2</sub>, less in 1% O<sub>2</sub> and none in 5% O<sub>2</sub> or in air. Periderm development was inhibited severely in  $\frac{1}{2}$  and 1% O<sub>2</sub> and slightly in 5% O<sub>2</sub> as compared to its development in air. This retardation persisted after removal of the tubers to air. Off-flavors and off-odors were severe in  $\frac{1}{2}$ % O<sub>2</sub>, and only mild in 1% O<sub>2</sub>, and absent in 5% O<sub>2</sub>. The off-odors and off-flavors disappeared during subsequent holding in air for 8 days. (MQ 2-84)

#### E. Postharvest disease control

1. Hot Water Treatment of Seed Potatoes. A hot water (140°F.) dip for 5 minutes compared favorably with the Semesan bel standard in controlling the new seed borne strain of common scab. However, the treatment markedly reduced yield and plant emergence. A 5-minute dip at 130° F. was ineffective compared with the best chemical treatments. A 5-minute dip at 130° F. before cutting gave excellent control of black leg and Rhizoctonia in pre-cut seed of the Russet Rural variety, and compared favorably with chemical treatments used. B-size whole seed of the Kennebec variety dipped in 130° F. water for 7 minutes showed a significant (5% level) increase in yield of U.S. #1 graded tubers as compared with a dry control. A 5-minute dip in 130° F. water failed to control Fusarium tuber rot (artificially inoculated) in a simulated packing study. (MQ 2-90)

### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

#### Quality Maintenance in Handling and Packaging

Hunter, J. H., E. F. Johnston, R. A. Ries, and J. B. Wilson. 1965. An evaluation of hopper-type and dump-type bulk truck bodies for potatoes. Maine Farm Res. 13(2):18-25. (MQ 2-93)

#### Quality Maintenance in Storage

Hruschka, H. W., P. C. Marth, and P. H. Heinze. 1965. External sprout inhibition and internal sprouts in potatoes. Amer. Potato Jour. 42: 209-222. (MQ 2-31)

Hunter, J. H. and H. V. Toko. 1965. Control of potato-storage diseases as affected by air flow, temperature and relative humidity. Amer. Soc. Agr. Eng. Trans. 8(4):578-580. (MQ 2-35 and 2-92)

#### Quality Maintenance in Transportation

Johnston, E. F., J. B. Wilson and L. N. Shaw. 1966. A comparison of mechanical bruising and transit temperatures of Maine potatoes when shipped in carloads of 50,000 and 60,000 pounds. Maine Agr. Expt. Sta. Misc. Pub. 674. (MQ 2-42)

Ries, R. A. and H. V. Toko. 1965. Bulk handling and quality evaluation of potatoes shipped in conveyORIZED railroad cars. USDA-ARS 52-8. (MQ 2-42)

### Postharvest Physiology

Craft, C. C. 1966. Localization and activity of phenolase in the potato tuber. Amer. Potato Jour. 43:112-121. (Pioneering Laboratory)

## PUBLICATIONS -- STATE EXPERIMENT STATIONS AND COOPERATIVE PROGRAMS

### Objective Measurement of Quality

De La Mar, Rosalita R. and F. J. Francis. 1965. Composition of the distillate in the alcohol test for quality of prepeeled potatoes. Proc. Amer. Soc. Hort. Sci. 86:511-516. (Mass.)

### Quality Maintenance in Handling and Packaging

Tereshkovich, G. and D. W. Newsom. 1965. Some effects of date of washing and grading on keeping quality of sweetpotatoes. Proc. Amer. Soc. Hort. Sci. 86:538-541. (La.)

Wurster, R. T. and Ora Smith. 1965. Potato quality. XX. After-cooking darkening in potatoes as related to the distribution of radioiron. Amer. Potato J. 42(1):37-44. (N. Y.)

### Quality Maintenance in Storage

Davis, C. O. and Ora Smith. 1965. Effect of transit and storage temperature of potatoes on chip color. Amer. Potato J. 42(1):7-14. (N. Y.)

Davis, C. O. and Ora Smith. 1965. Potato quality. XXVI. Darkening of frozen potato products resulting from exposure to ammonia vapor. Amer. Potato J. 42:127-133. (N. Y.)

Kushman, L. J. and F. S. Wright. 1965. Overhead ventilation of sweet-potato storage rooms. N. C. Agr. Expt. Sta. Tech. Bul. 166, 29 pp. (N.C.)

Sawyer, R. L., et al. 1965. Potato storage research on Long Island with forced-air ventilation systems. N. Y. (Cornell) Agr. Expt. Sta. Bul. 1002, 31 pp.

## AREA 10

## POULTRY PRODUCTS - MARKET QUALITY

Problem. Technological developments continue in the poultry industry and create many new problems relating to the market quality of poultry and egg products. Introduction of highly mechanized equipment and machinery plus new techniques in processing affect the absorption and retention of moisture of ready-to-cook poultry, the contamination of poultry and egg products by spoilage microorganisms, the physical damage to poultry carcasses, and the sanitary and functional properties of egg products. To maintain quality of these products in marketing channels, more information is needed regarding the effects of the new technology as well as changes that occur during transportation and storage. In addition, objective methods of quality evaluation are needed for use in developing improved criteria and standards for inspection and grading to insure uniform, standardized, and wholesome products.

## USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving food technologists and bacteriologists engaged in basic and applied research in the quality evaluation and quality maintenance of poultry products. The research is conducted at Beltsville, Maryland, Athens, Georgia, and through a research contract with the University of Iowa, Ames, Iowa.

The Federal scientific effort devoted to research in this area totals 4.8 scientific man-years; objective measurement and evaluation of quality, 3.8, and handling, packaging and storage, 1.0.

## PROGRAM OF STATE EXPERIMENT STATIONS

A total of 12 scientist man-years is devoted to this area of research.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Quality Measurement and Evaluation of Quality

1. Detection of Salmonella in Egg and Poultry Products. A simple method of detecting Salmonella negative samples of dried whole egg within 48 hours has been developed. The technique consists of incubating a sample of egg in a jar of lactose pre-enriched broth containing a tube of SIM agar and one of mannitol agar. Absence of both H<sub>2</sub>S production and mannitol fermentation after 42 hours of incubation indicate that the sample is Salmonella negative.

Of 225 samples of commercially pasteurized dried whole egg, two-thirds of the 217 confirmed negative samples were identified by this method. Employing the conventional methods, 96 hours were required to detect only 118 of the negative samples. All eight confirmed positive samples were presumptively positive by the new technique. (MQ 3-74)

2. Lighting Requirements for Proper Grading and Inspection of Poultry. A survey conducted in the Delmarva area showed a large variation in the kind and amount of light used at inspection and grading stations in poultry processing plants. A study was initiated to ascertain the parameters of an adequate visual environment for inspectors and graders. Twelve different lighting systems were evaluated by a 12-member panel who judged selected pairs of color chips which approximate the colors most critical in the inspection and grading of individual carcasses. For each pair of chips, judges were asked to indicate whether the two chips matched or were different in color when presented under each of the lighting situations at both 50 and 100 foot candles. Preliminary analysis of the data for the lower intensity, 50 foot candles, showed considerable variation between lamps on the basis of total erroneous judgments by each judge. Intensive analysis of the data is currently underway. (MQ 3-52)

#### B. Quality Maintenance in Handling, Packaging and Storage

1. Control of Salmonellae on Eviscerated Chickens. Eviscerated fryer chickens inoculated with S. typhimurium were spray treated with plain water (controls), citric acid, succinic acid, B-propiolactone, aureomycin, neomycin, or 20, 100, or 200 ppm chlorine solutions under conditions that simulated practical plant conditions. Only treatment with 100 or 200 ppm chlorine was significantly more effective than plain water in reducing Salmonellae counts. Washing after treatment also significantly reduced Salmonellae counts. (MQ 2-75)

2. Packaging of Eviscerated Chickens. The effect of evacuated, heat-shrunk packaging of fresh chickens on drip loss, shelf-life and general appearance was determined in a cooperative study with the Department of Poultry Science, University of Maryland. The treatments studied were: (1) non-evacuated bag (control); (2) evacuated bag; (3) heat-shrunk evacuated bag; (4) heat-shrunk, wax-coated, evacuated bag. The packaged birds were stored at  $1.7 \pm 0.5^{\circ}\text{C}$ . and sampled for drip loss, appearance, and bacterial populations at day of packaging and at eight intervals thereafter until the 22nd day of storage. Drip losses from birds packaged in evacuated bags were lower than the drip losses in the non-evacuated controls. Differences in total aerobic bacterial counts among birds packaged by the four methods were considered unimportant when birds were stored up to 14 days. Odor scores indicated that birds in evacuated, wax-coated bags developed objectionable odor later than did birds of the other three treatments. Birds in the evacuated heat-shrunk packages and birds in the evacuated heat-shrunk, wax-coated packages had more eye appeal than the birds in the non-evacuated bags. (Exploratory Work)

3. Microbiology of "Further-Processed" Turkey Products. A study to determine the incidence and source of Salmonellae, staphylococci and total aerobes in turkey rolls was initiated under contract with Iowa State University. Samplings were made from ready-to-cook turkeys, materials, equipment and hands of plant personnel for determination of Salmonellae and other bacteria at various stages during commercial processing cooked turkey rolls that are marketed in the frozen state. Finished raw rolls before freezing appeared to yield greater recoveries of Salmonellae than did the chilled but unfrozen carcasses used for making the rolls. Examination of 37 turkey rolls after cooking in commercial water baths revealed no Salmonellae. Limited data on numbers of aerobes, coliforms and enterococci on chilled carcasses and meat at various stages of preparation and rolls before cooking indicated that wide ranges may be expected within these three groups of bacteria. No correlation was observed between these counts and presence of Salmonellae. Salmonellae were found on various types of equipment and utensils in plants. Data concerning incidence and serotypes are being evaluated to obtain a more complete picture of the dissemination of these organisms throughout processing operations. (MQ 2-113(C))

Work was initiated to determine and eliminate the source of microbial contamination of dry-heat cooked turkey rolls that are marketed in the refrigerated condition. Cooking juices and spices used in preparation of this type of roll, as well as skin and internal meat of finished rolls obtained from four commercial plants were examined for numbers of aerobes, psychrophiles, coliforms, enterococci, molds, and yeasts. Celery, onion, pepper and cooking juices were found to be highly contaminated with both mesophilic and psychophilic bacteria. Samples of typical cooking juice - spice mixtures that are added to turkey rolls after cooking (immediately prior to packaging) were heated to 160, 180, 200, and 212°F. to determine the effect of such heat treatments on destruction of viable microorganisms. These data are being analyzed. (MQ 2-121)

4. Changes in Eggs During Cold Storage. Thick/thin white ratio, viscosity, pH, and Haugh units were found to be inter-related in oiled and unoiled eggs stored at 0° and 15°C., and unoiled eggs in a CO<sub>2</sub> atmosphere at 0°C. Ovomucin content and characteristics in egg white fractions were determined by specific electrical conductivity, paper electrophoresis and paper chromatography. In eggs stored for six months, ovomucin content tended to increase in thin egg white, and decrease in thick egg white. Ovomucin was found to be polydisperse. Further evidence is required to establish the quantitative relationship between amino acids and ovomucin electrophoretic fractions. (E25-AMS-8(a))

5. Maturity Studies. Preliminary investigations of uptake of radioactive strontium (85 and 87), by bones of White Leghorn and New Hampshire chickens of various ages were completed. Monitoring procedures proved effective. One-hour measurements of radioactivity of the epiphyses centers of the tibia of birds 4, 6, and 10 weeks of age yielded a constant assimilation rate. Older birds are being evaluated to determine whether the assimilation rate will change. (Exploratory Work)

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Measurement and Evaluation of Quality

- Kotula, A. W. 1966. Variability in microbiological samplings of chickens by the swab method. Poultry Science 45:233-236. (Exploratory Work)
- Sadler, W. W., R. Yamamoto, and R. E. Corstvet. 1965. Bacteriological survey of market poultry livers. Poultry Science 44:993-998. (MQ 3-22(C))
- Sadler, W. W., and R. E. Corstvet. 1966. The effect of Erysipelothrix insidiosa (rhusiopathae) infection on wholesomeness of market turkeys. American Journal of Veterinary Research 26:1429-1436. (MQ 3-22(C))
- Sadler, W. W., and R. E. Corstvet. 1965. The efficacy of ante-mortem inspection in supplementing the post-mortem inspection of poultry. Avian Diseases 9:441-459. (MQ 3-22(C))
- Sadler, W. W., and R. E. Corstvet. 1965. The effect of experimental mycoplasma synoviae infection in the wholesomeness of young market age chickens. American Journal of Veterinary Research 26:1413-1420. (MQ 3-22(C))
- Sadler, W. W., and R. E. Corstvet. 1965. Effect of experimental mycoplasma synoviae infection on the wholesomeness of young adult turkeys. American Journal of Veterinary Research 26:1421-1428. (MQ 3-22(C))

Quality Maintenance in Handling and Packaging

- Thomson, J. E., A. J. Mercuri, J. A. Kinner, and D. H. Sanders. 1966. Effect of time and temperature of commercial continuous chilling of fryer chickens on carcass temperatures, weight and bacterial counts. Poultry Science 45:363-369. (MQ 2-75)
- Kotula, A. W., and N. V. Helbacka. 1966. Blood retained by chicken carcasses and cut-up parts as influenced by slaughter method. Poultry Science 45:404-410. (MQ 2-81)
- Kotula, A. W. 1966. Poultry in the convenience food market. The Maryland Poultryman. January, pp. 2-4, 7. (MQ 2- and 3- )

## PUBLICATIONS -- STATE EXPERIMENT STATIONS AND COOPERATIVE PROGRAMS

Objective Measurement and Evaluation of Quality

- Cotterill, Owen J. 1965. Evaluation and measurement of quality of poultry and eggs. In Food Quality, ed. by G. W. Irving, Jr., and S. R. Hoover, pp. 179-191. (Missouri)

- Essary, E. O., and L. E. Dawson. 1965. Quality of fryer carcasses as related to protein and fat levels in the diet. I. Fat deposition and moisture pick-up during chilling. Poultry Science 44(1):7-15. (Virginia)
- Meredith, W. E., H. H. Weiser, and A. R. Winter. 1965. Chlortetracycline and oxytetracycline residues in poultry tissues and eggs. Applied Microbiology 13(1):86-88. (Ohio)
- Pangborn, Rose Marie, Nancy Sharrah, Harriet Lewis, and A. W. Brant. 1965. Sensory and mechanical measurements of turkey tenderness. Food Technology 19(8):86-90. (California)
- Sluka, S. J., E. L. Besch, and A. H. Smith. 1965. A hydrostatic tester for egg shell strength. Poultry Science 44(6):1494-1500. (California)
- Taylor, M. Hal, Jack L. Fry, and Lewis T. Smith. 1965. Factors affecting quality and tenderness in turkey steaks. Poultry Science 44(3):669-673. (Kansas)

#### Quality Maintenance in Handling, Packaging and Storage

- Hartung, T. E. 1965. The influence of temperature and bag breakage on the quality of frozen turkey carcasses. Poultry Science 44(2):459-466. (Colorado)
- Miller, W. O., and K. N. May. 1965. Tenderness of chicken as affected by rate of freezing, storage time and temperature, and freeze drying. Food Technology 19(7):147-150. (Georgia)
- Peterson, C. F. 1965. Factors influencing egg shell quality. World's Poultry Science 21(2):110-117. (Idaho)

## AREA 11

## TOBACCO - MARKET QUALITY

Problem. Stored tobacco and tobacco products are subject to insect damage that seriously affects the grade, value, and potential end use. The price support program has resulted in a large buildup of stocks, some held for as long as seven years, about twice the normal period for storage and aging. The long-term storage and the compact, dense structure of the tobacco as stored in hogsheads make insect control difficult. Repeated, heavy applications of fumigants or other control measures during extended storage has raised a question as to the extent and significance of residues that may be accumulated. Treatments applied during storage should be assessed further to be sure they are safe. Measures now used only hold insect populations in check and do little to reduce them or prevent them from becoming established. Attention should be given to the development of measures that will minimize or eliminate the use of chemicals, and at the same time eliminate or prevent infestations. To accomplish this it will be necessary to develop much more basic information than is now available on the ecology, physiology, and behavior of the insects that attack stored tobacco. Various fungi, bacteria, and viruses are found in tobacco. It is becoming quite apparent that the quantity of phenolic compounds is increased markedly in diseased plant tissue, including tobacco leaf. These substances may affect mammalian physiology. Research is needed to determine the changes that occur in the composition of tobacco leaf as the result of the metabolic activities of pathogens and to characterize the organisms that constitute the nonpathogenic microflora associated with tobacco leaves.

## USDA AND COOPERATIVE PROGRAM

The Department has a continuing program headquartered at Richmond, Virginia, involving basic and applied research in entomology, directed toward the insect problems of tobacco and tobacco products in the marketing channels. The research is conducted in cooperation with farmers' cooperative associations, industry groups, and the Agricultural Stabilization and Conservation Service of this Department. The Federal effort devoted to this program is temporarily only 1.0 scientist man-year because of the inability to find qualified personnel to fill two vacancies. Some of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect control in marketing channels," applies to the insect problems in stored tobacco.

Line Project MQ 1-33, a study of residues resulting from tobacco fumigation, was discontinued because of lack of personnel.

The Department is conducting quality research at Raleigh, North Carolina and under contract and cooperative agreement with the Agricultural Experiment Station of the University of Kentucky, Lexington, Kentucky. Federal effort amounts to 5.2 scientific man-years.

## PROGRAM OF STATE EXPERIMENT STATIONS

A total of 3 scientist man-years is devoted to this area of research.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

### A. Prevention of Insect Infestation

1. Biological and Physical Control. The remainder of the basic data were obtained on temperature, absolute pressure and exposure time that were required to complete the mortality curve for the tobacco moth in relation to the vacuum-steam flow system for treating tobacco. A manuscript has been prepared to publish the information. (MQ 1-37)

2. Biology and Ecology. Living cigarette beetle larvae were found at depths of 4 to 20 inches of tobacco in heavily infested hogsheads held at 48°F. for more than 20 weeks. The study is to investigate the effect of low temperature on the cigarette beetle in the natural environment of the tobacco hogshead. The tobacco temperature ranged between 50 and 52°F. Numerous living larvae were present at the time of final inspection but the number of live insects was inversely proportional to the length of exposure. Living adults found in the later inspections are believed to be from pupae that transformed even at the low temperature of 50 to 52°F. Further observations will be made until complete mortality occurs. Additional studies will be made at 40°F.

(MQ 1-7(Rev.))

Third and fourth instar larvae of the cigarette beetle to be used in low-temperature studies in the laboratory were preconditioned by gradual reduction of temperature from 80 to 60°F. over a four-day period. During this time the larvae doubled their average weight. When the larvae were then held at 40°F. there was a continuing loss in weight and within three weeks, there was heavy mortality. (MQ 1-7(Rev.))

3. Improved Pesticidal Control. Laboratory tests of residual and vapor action were conducted with 19 compounds against cigarette beetle adults. Shell compound SD 9020 showed extended residual and vapor action. Five other promising compounds were American Cyanamid 47300, Dursban, Hoestachem 2838, and Stauffer compounds N 3727 and R 8963. Although Bromodan was somewhat less effective than some other materials in laboratory tests, it was of considerable interest because of its extremely low mammalian toxicity, along with short residual life and specificity in its vapor action. Therefore, it was evaluated in a larger scale test but it was not effective.

(MQ 1-35)

Several hundred hogsheads of tobacco were sold after storage four to five years in warehouses fumigated heavily with HCN each spring, then treated twice weekly with dichlorvos during the insect season. Insect damage did not exceed trace amounts. To determine whether the number of fumigations can be reduced, other warehouses were given one HCN fumigation and treated with dichlorvos five days a week during the insect season. After two years, only a few insects were present and no damage to tobacco was detected. To determine whether fumigation could be eliminated, new crop tobacco was placed in six new warehouses and dichlorvos applied five days a week during the insect season. After  $1\frac{1}{2}$  years of storage, the insect population appeared to be increasing and some damaged tobacco was found. The treatments discussed are carried out by industry. The Department functions only as an advisor and observer, but is able to obtain valuable information. (Unclassified)

## B. Quality Maintenance

1. Effect of Post-Harvest Microflora on Tobacco Composition. Preliminary findings in this project indicated that at least twenty-two genera of fungi were associated with air-cured burley tobacco of different marketing grades. (MQ 2-109)

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

### Prevention of Insect Infestation

Childs, Dana P. 1965. Laboratory evaluation of insecticides against the cigarette beetle. Abstract in Bul. Ent. Soc. Amer. 11(3):178. (MQ 1-35)

Childs, Dana P., G. L. Phillips, and Arthur F. Press, Jr. 1966. Control of the cigarette beetle in tobacco warehouses with automatic dichlorvos aerosol treatments. Jour. Econ. Ent. 59(2):261-264. (BS 1-3(Rev.))

Press, Arthur F., Jr., and Dana P. Childs. 1966. Control of the tobacco moth with dichlorvos. Jour. Econ. Ent. 59(2):264-265. (BS 1-3(Rev.))

U. S. Department of Agriculture, Market Quality Research Division. 1965. Stored-tobacco insects -- biology and control. Agriculture Handbook No. 233, 39 pp., slightly revised September. (MQ-1)

## PUBLICATIONS -- STATE EXPERIMENT STATIONS AND COOPERATIVE PROGRAMS

### Objective Measurement and Evaluation of Quality

Henson, W. H., Jr., and F. J. Hassler. 1965. Certain dielectric and physical properties of cured tobacco leaves. Humidity and moisture 2: 148-160. Reinhold Publishing Co., New York, New York. (Kentucky)

- Henson, W. H., Jr., and F. J. Hassler. 1965. Certain dielectric and physical properties of intact tobacco leaves. Tobacco Science 9:121-127. (Kentucky)
- Young, J. H., J. M. Bunn, and W. H. Henson, Jr. 1965. Humidity and moisture problems associated with the handling and storage of cured tobacco. Humidity and Moisture 2:231-238. Reinhold Publishing Co., New York, New York. (Kentucky)

## AREA 11 b

## CUT FLOWERS AND ORNAMENTALS - MARKET QUALITY

Problem. The rapid increase in production of field-grown narcissus, gladiolus, lilies, stocks, and chrysanthemums into a multimillion dollar business in Florida, California, and other states has raised many problems in marketing. Methods of packaging, as related to cooling and market life, temperature requirements during transport and for limited storage periods, atmosphere modifications for storage and transit for both cut flowers and ornamentals, and the control of Botrytis rot are among the most urgent research needs.

## USDA AND COOPERATIVE PROGRAM

The Division has a limited program in market quality research on cut flowers and ornamentals, amounting to approximately 2.0 scientist man-years. This research is conducted at the Fresno and Beltsville laboratories and at the Gulf Coast Experiment Station under a cooperative agreement with the Florida Agricultural Experiment Station. The California work is supported in part by the California Floral Traffic Conference and the California Florist Association.

No projects were terminated during the year.

## PROGRAM OF STATE EXPERIMENT STATIONS

A total of 6 scientist man-years is devoted to this area of research.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Quality maintenance in storage

1. Storage Life and Respiration of Daffodils. Field-grown trumpet narcissus (daffodils) were found to have a postharvest life in air of 1 - 2 days at 80° F., 2-3 days at 70°, 3-4 days at 60°, 7-8 days at 50°, 8-12 days at 40°, and 10-21 days at 32°.

Respiration rates of freshly harvested daffodil flowers decreased rapidly to about 1/3 of the original value in 12 hours at 32° or 40° F., then declined very slowly during 3 additional days of storage. At 50 or 60° the rate declined more slowly to about 2/3 of the original rate after 24 hours and remained nearly constant for several additional days. Transfer of the

flowers from 32° and other low temperatures to 70° produced an immediate rapid increase in respiration up to 900% in some instances which usually reached a maximum within 20 hours after transfer. When separated into parts the flowers respired at about 2½ times the rate of the stems and 50% higher than flowers with stems attached. No relationship between the amounts of carbon dioxide evolved in air or in nitrogen and the display life of the flowers was observed. Storage life varied from 3 to 5 days at 60° to 2 to 3 weeks at 32° or 40°. (MQ 2-105)

2. Respiration of Carnations. Low oxygen atmospheres ( $\frac{1}{2}$ , 1, or 2% O<sub>2</sub>) reduced the respiration rate of carnations by 45, 40, or 30%, respectively. However, the 2% O<sub>2</sub> atmosphere had very little effect on the quality or post-storage life of the blooms. Holding the stems in water during storage in a normal atmosphere increased the respiration rate by 30%, compared to dry storage. When stored in 1% O<sub>2</sub>, respiration of blooms with stems in water was 25% greater than of those stored dry. The effects of low O<sub>2</sub> were sufficient to reduce respiration of blooms in water stored at 1% O<sub>2</sub> below that of those stored dry in air. The deterioration in quality roughly paralleled the respiration rates under these conditions. (MQ 2-105)

3. Effects of Storage Techniques on Gladiolus Flowers. Generally post-storage quality of gladiolus was better as storage temperatures were reduced from 50° to 35° F. or as the length of storage period decreased. Packaging techniques which reduced moisture loss in storage enhanced flower keeping quality. Spikes stored in nitrogen atmospheres were not superior to those stored in air. (MQ 2-117)

4. CA Storage of Carnations. Quality and storage life of carnations was best at 36° F. when the blooms were held in an atmosphere with 1/2 to 1% oxygen as compared with higher oxygen concentrations. A continuous flow of air through the storage chamber maintained quality almost as well as the low oxygen atmospheres and much better than static air in the chambers. More post-storage display life was added by placing the stems of flowers in preservative solutions (compared to water) after storage than by the use of CA or a continuous flow of air during storage. (MQ 2-105)

5. Ethylene Effects on Carnations. Early-season varieties of strawberries from the Fresno area did not produce "sleepiness" in carnations, but when later varieties from the coastal areas of California were held together with carnations for 5 days at 59°, this effect was observed on the flowers after 1 day at 70°. One kilogram of strawberries in a chamber produced about 1.5 ppm ethylene in an airstream (5 ml/min.) which was passed over carnations in another chamber. Preliminary determinations indicate that ethylene concentrations above 1/2 ppm cause sleepiness. A brominated-activated charcoal filter in the line prevented sleepiness. Carnation blooms produced substantial amounts of ethylene when they were "sleepy". Preliminary tests showed that .013 ml of ethylene were produced per hour by 100 grams of sleepy blooms compared to only a trace (unmeasurable) by healthy blooms of the same age. (MQ 2-105)

## B. Postharvest disease control

1. Control of Botrytis Decay. Each of the twenty natural amino acids (1,000 ppm) were added to a balanced nutrient solution containing 2% glucose to determine the requirements of Botrytis cinerea. All significantly increased the growth when compared to the nutrient solutions without amino acids. Four analogs were also used in liquid nutrient media. B. cinerea was capable of utilizing only DL-2-methyl leucine. Experiments were conducted to test the effectiveness of certain amino acid analogs used as post-harvest sprays for control of B. cinerea on rose (American Red Beauty), gladiolus (Rose Spire) and B. gladiolorum on gladiolus. DL-ethionine at 1000 ppm was effective in controlling B. cinerea infection on rose flowers and gladiolus florets following artificial inoculations. The antimetabolite relationship was demonstrated by a failure to control infection with a 1:1 ratio of DL-ethionine to L-methionine. Exposing conidia to DL-ethionine reduced the percentage of germination and length of germ tubes. Decay reduction with DL-ethionine is fungistatic rather than fungicidal. Infection caused by B. gladiolorum was reduced on gladiolus florets by spraying spikes 1 hour before inoculation with DL-ethionine or m-fluoro DL phenylalanine at 500 or 100 ppm. (MQ 2-117)

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

None.

## PUBLICATIONS -- STATE EXPERIMENT STATIONS AND COOPERATIVE PROGRAMS

### Objective Measurement and Evaluation of Quality

Rogers, Marlin N. 1965. Chemical growth retardants for poinsettias. Mo. State Flor. News 26(4):3-8. (Mo.)

## AREA 12

## VEGETABLES - MARKET QUALITY

Problem. Most fresh vegetables are highly perishable. Research is needed on sources of inoculum and time of infection and physical and chemical methods for decay reduction. Basic studies are needed on cell metabolism as related to the causes and control of functional disorders and the nature of ripening and aging. Product quality as related to mechanical harvesting will need increasing study as will the effects of storage environment on keeping and eating quality. Safe and effective transportation can be accomplished only by continued research with transportation services, equipment, and methods as these affect ultimate quality of the product in the market. The increasing interest in liquid gases for transit refrigeration and atmosphere modification has posed a series of new problems relating to effects on the commodities from release of substantial amounts of nitrogen or carbon dioxide in the load compartments. Additional information is needed on objective indices for harvest maturity and quality factors as related to standardization and grading, and practical measurements for quality changes as the product moves through marketing channels.

## USDA AND COOPERATIVE PROGRAM

The Department has a continuing program of applied and basic research relating to quality measurement and protection of vegetables as they pass through the marketing channels. The work is conducted by horticulturists, plant pathologists, plant physiologists, and food technologists.

Research is conducted at USDA laboratories in Beltsville, Md.; Fresno, Calif.; Miami, Fla.; Orlando, Fla.; Belle Mead, N. J.; Chicago, Ill.; and Harlingen, Texas, and at the North Carolina Agricultural Experiment Station, Raleigh, N. C.

Projects terminated during this period included gray mold of peppers (MQ 2-52), host-parasite physiology of market diseases (MQ 2-60), injury, decay and shrinkage of sweetpotatoes (MQ 2-73), gamma radiation on market life (MQ 2-82), chilling injury of eggplant (MQ 2-86), ripening of tomatoes (MQ 2-88), and antioxidants and metabolic inhibitors (MQ 2-61).

## PROGRAM OF STATE EXPERIMENT STATIONS

A total of 23 scientist man-years is devoted to this area of research.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Sweetpotatoes. Correlation coefficients between carotene content and various color parameters (Hunter L,  $a_L$ ,  $a_L/L$ , X/Y and  $\cos\theta/L$ ) for either raw or canned roots were highly significant. Tested by the conventional Z- $X^2$  test, they were not significantly different from each other.

Percent reflectance at 480, 500, 520 and 540 nm was determined from spectrophotometric curves of 5 to 10 raw roots. Conversions to relative reflectance by wavelength were correlated with carotene content. The correlation between relative reflectance and carotene content was highly significant at all four wavelengths. The highest value ( $r=0.858$ ) was obtained at 500 nm. (MQ 3-50)

B. Quality maintenance in handling and packaging

1. Lettuce. Weight loss during the holding of film-wrapped New Jersey lettuce was greatly influenced by humidity in the storage room air and by degree of perforation in film overwraps. Least moisture loss occurred in polystyrene wrapped lettuce at all humidities. Moisture loss and decay were inversely related. More decay in inoculated lettuce developed at 90 percent relative humidity than at the lower humidities. Generally, heads wrapped in the multiperforated films, polyethylene, polypropylene, polyvinyl chloride A and perforated cellophane had the least number of decayed heads. However, dehydration of outer leaves resulted in trimming losses in heads wrapped with these films at the lower humidities, especially in the more perforated ones. The most decay developed in lots overwrapped with the non-perforated polystyrene and the needle-perforated polyvinyl chloride B films. Usually more decay developed when polystyrene and polyvinyl chloride overwraps were heat-shrunk than when they were not heated. (MQ 2-80)

2. Rhubarb. Bunched, debladed rhubarb stalks stored in polyethylene-lined crates or in bunches in polyethylene remained acceptable at 32° F. and 85-95% relative humidity for 4 weeks plus one day at 70°; at 40° for 2 weeks plus 1 day at 70°; and at 50° for 1 week plus 1 day at 70°. Weight loss was less than 1% during 4 weeks at 32°. Abscission of petiole bases was found in stalks stored 2 weeks or longer at 32° or 40° in film liners or wraps and then held 1 day or longer at 70°. Dipping stalks in water at 125° F. for 2 minutes before cutting into one-inch pieces and packaging in perforated polyethylene film bags, reduced decay and extended shelf life an extra day at 70° beyond 1 day shelf life for non-treated pieces. (MQ 2-61)

C. Quality maintenance in storage

1. Sweetpotatoes. Detailed records were obtained in a new sweetpotato storage with trench heating and humidification and an overhead ventilation system. Temperatures and relative humidities were controlled within  $\pm 5^\circ$  F.

and 10% of optimum, respectively, during October through April. Trenches 9 feet apart were better than those 18 feet apart. Air circulation was adequate when heat was supplied through the trenches by an oil-fired, forced-air furnace but fans were needed with electric strip heating. No chilling injury was detected and no chilling temperatures recorded even though outside air temperature dropped to 5° F. during a storm. Palletized field boxes of sweetpotatoes were cured about 7 days before moving to the storage room. No injury or decay resulted from carefully moving the pallet loads of sweetpotatoes with a fork lift.

Intercellular space of sweetpotatoes varied between 4 varieties at harvest but varied less than 1.5% within a variety from 3 harvest dates and 3 locations. Roots of two varieties of sweetpotatoes lost weight and volume continuously during curing at 85° F. and 85-90% RH. All roots continued to lose weight during storage at nearly the same rate. Those that had the long cures (14 to 35 days) were more pithy after storage than those cured for 3 or 7 days. (MQ 2-128)

2. Controlled Atmosphere Storage of Cauliflower. Exposure to high CO<sub>2</sub> atmospheres during storage or marketing causes discoloration and excessive softening of cauliflower (if it is cooked) soon after removal from the modified atmosphere. The physiological changes associated with this disorder appear to be reversible. Discoloration of California cauliflower, cooked immediately after removal from an atmosphere containing 15 percent CO<sub>2</sub> and 5 percent O<sub>2</sub> (7 days at 41° F.), was measured on a Hunter Color Difference Meter and had an average reflectance value of 37, whereas after 24 hours' exposure to air the reflectance value was 41. Shear-press resistance increased from about 40 lb. to 70 lb. during the same interval. The differences for both criteria are significant at the 99 percent probability level.

Texas cauliflower held in near-zero level of CO<sub>2</sub> in all reduced oxygen atmospheres had slightly better texture than those stored with 5 or 10% CO<sub>2</sub>. An off-flavor was detected in cooked cauliflower previously held in either 5 or 10% carbon dioxide with 10% oxygen but not at 1 or 5% oxygen. (MQ 2-123)

3. Symptoms of Freezing Injury. External and internal watersoaking was present in about 30% of cucumbers held at 20° F. for 1 hour, and in 83% of those held 2 hours. Exposure for 1 hour or longer at 0° F. generally resulted in 100% external watersoaking. Watersoaking present immediately after freezing persisted throughout a 1-day holding period at 40° or 70°. Frozen cucumbers lost less than 1% moisture when held 1 day at 40° or 70° but shrivel was noted at both temperatures. Pitting developed on the surface of frozen cucumbers held at 70° for 1 day but not on those held at 40°.

Watersoaking was noted in 12% of freshly-harvested asparagus spears 20 minutes after being placed at 20° F. After 40 minutes, watersoaking was present in 62% of the spears. When asparagus was held at 0°, 72% of the spears were watersoaked after 20 minutes. The watersoaked appearance persisted after freezing. A 9% moisture loss, which occurred principally in watersoaked areas, caused severe shrivelling in frozen asparagus held 1 day at 70°.

After slight freezing watersoaking was observed in turnips in scattered, small, circular spots. After severe freezing the spots were coalesced into larger, solidly watersoaked areas most easily observed on the non-colored portion of the root. A "blistered" appearance, due to the formation of ice crystals between the skin and the flesh, was commonly noted on severely frozen turnips. When moderately or severely frozen, the turnips recovered much better at 40° than at 70°. (MQ 2-29)

#### D. Quality maintenance during transportation

1. Asparagus. Asparagus was exposed to variable and above-optimum temperatures (43° to 57° F.) during transit from California to New York when shipped in a nitrogen-refrigerated rail car. Decay at the butt end occurred in 70 to 90% of the spears in the warmest positions and in 10% of those in the coolest positions in the car. The spears grew 1 to 3 inches during transit at the warm locations. Spears in crates stacked directly under the gas discharge lines were injured by freezing.

Asparagus held at 60° F. respired about three times as fast in air as in 100% nitrogen. In the nitrogen atmosphere spears developed a "cooked" appearance, softened and had an offensive odor. Asparagus held in nitrogen at 33° for 9 days also developed a "cooked" appearance and a slight off-odor. Spears held in air remained in good condition for the entire period. Respiration rates of asparagus at 33° F. in atmospheres containing 1% and 1/4% oxygen were about 94% and 80%, respectively, of those in air. Injury was observed in spears from the 1/4% oxygen atmosphere but not in spears from 1% oxygen. Shear press readings indicated no difference in tenderness of asparagus held in nitrogen or in air at either 33° or 60° F. However, asparagus remained much more tender at 33° than at 60°.

In studies of the effect of high initial concentrations of CO<sub>2</sub> on asparagus quality, controlled leakage rates reduced the CO<sub>2</sub> concentration from an initial 20% by one-half every 7 hours (fast rate) or every 16 hours (slow rate). After 7 days at 36° or 41° F., decay was negligible in all lots. After an additional 2 days at 59° in air, about 19% of spears held in air only showed soft rot of the tips while only 5 to 10% of those receiving the initial CO<sub>2</sub> showed this decay. The benefits of the high initial CO<sub>2</sub> atmospheres were not evident in tests where the general decay level was low. Taste tests revealed no objectionable off-odors or off-flavors in the CO<sub>2</sub> treated spears. (MQ 2-84 and 2-71)

2. Lettuce. When liquid nitrogen was the only source of refrigeration, temperature variations within the load were excessive and maximum lettuce temperatures were high. More decay developed in lettuce in these trailers than in trailers that were mechanically refrigerated. However, russet spotting was reduced in the low oxygen atmospheres resulting from nitrogen refrigeration. Trailers having mechanical refrigeration supplemented with liquid nitrogen to modify the atmosphere gave a significant reduction in russet spotting with no increase in decay, when compared with conventional

mechanically-refrigerated trailers. About one-fourth of the conventional trailers had average load temperatures of 40° F. or higher during transit, even though all but one thermostat was set at 36° or lower. The average transit temperature of lettuce in all trailers of this type was 38°.

The general appearance (primarily color and freshness) of non-trimmed lettuce was not affected significantly by holding it one week at 36° or 41° F. in 1/2 to 8% oxygen. However lettuce held for one week at 50° in 1, 2, 5 or 8% O<sub>2</sub> and 3 or 4 additional days in air appeared significantly greener and fresher than that held in air throughout. The quality of lettuce held in air at 36° or 41° was equal to and often superior to that held in low O<sub>2</sub> at 50°. The rate of respiration (CO<sub>2</sub> production) of lettuce was reduced by about one-third to one-half in 1/2, 1, or 5% O<sub>2</sub> as compared with that in air.

Texas lettuce held 2 weeks in reduced oxygen levels with zero carbon dioxide showed no internal browning after 1 week in air. In contrast, heads from similar oxygen levels with either 5 or 10% carbon dioxide showed moderate to severe internal browning with those from the higher level completely worthless. Lettuce stored in air was equal in appearance to that held in zero carbon dioxide at all levels of reduced oxygen. (MQ 2-84)

3. Kale. Three samples of freshly cut kale were held 10 days at 36° F. under the following conditions: (1) in air; (2) in an atmosphere in which the oxygen was gradually depleted by respiration with a resultant build-up of carbon dioxide; and (3) in a similar atmosphere but with the carbon dioxide absorbed. The kale in condition (2) developed a bad odor by the seventh day at which time the atmosphere was 0.2% oxygen and 6.8% carbon dioxide. The off odor disappeared within 24 hours after the kale was placed in air. Kale held under conditions (1) or (3) retained normal odor and flavor. (MQ 2-71)

#### E. Postharvest physiology

1. Respiration of Minor Crop Vegetables. Topped radishes respire at a rate of 3-9 mg. CO<sub>2</sub>/kg./hr. at 32° and 60-89 at 80°. Radishes with tops respire 2 to 3 times more rapidly. Green onions respire at a rate of 10-22 at 32° and 98-210 at 80°. Rhubarb stalks without leaves respire at a rate of 8-13 at 32° and 40-57 at 70°, and twice these rates with leaves attached. Yellow Straightneck summer squash respire at a rate of 12-13 mg. CO<sub>2</sub>/kg./hr. at 32° and 85-97 at 70°. (No Line Project)

2. Russet Spotting of Lettuce. During 1965, six tests were conducted to determine whether a relationship exists between the incidence of russet spotting and mild field virus infections in lettuce. Lettuce with obvious mosaic symptoms had about half the incidence of russet spotting in the initial 5 tests as those with no visible symptoms cut from the same area of the field. In a sixth test, results were similar when lettuce was cut from the same area of a field. However, heads obtained from an apparently virus free area of the same field developed less russet spotting than those from the infected area which showed no symptoms. (Exploratory)

3. Translucent Scale of Onions. Preliminary results of tests involving approximately 1500 pounds of onions indicate that bruising by simulated commercial handling creates a translucent condition of the onion scale which might easily be confused with translucent scale described as due to physiological breakdown. It appears that there is a degree of recovery which is proportional to time after the bruising and temperature at which the onions are held. Onions held at room temperature and humidity recovered faster than those held at 40° and higher relative humidities. (MQ 2-111)

#### F. Postharvest disease control

1. Onions. The control of onion neck rot with heat treatments at harvest was better with fully mature onions than those less mature. However, results with either hot plate or flame treatments to the cut neck surfaces were erratic.

Preharvest treatments of the soil with 70 to 560 grams of hydrated lime per 5' by 20' plot failed to reduce decay of onions in storage. The higher concentrations of lime appeared to increase decay. Captan-50 wp and Difolatan 75% dusted on the freshly cut neck surfaces were the most effective treatments. Dusts of 6% Botran, Dithane 22, Calcium Chloride and Daconil 2787 were less effective. Decay after 4 to 5 months in common storage was 79% in the controls and 8.3 and 3.3% in the best treatments. Muck soil mixed with inoculum was applied to the cut surfaces following treatment in all lots. (MQ 2-95)

2. Soft Rot in Bell Peppers. Harvested peppers from controlled nitrogen fertilizer plots were inoculated with soft rot bacteria to determine any difference in their susceptibility to infection. Also, some inoculated pods were treated with hot water (128° for 1.5 minutes) to determine any difference in reduction of infection. Pods from the high nitrogen plots showed nearly the same percentage of positive infections (80%) as pods from the low nitrogen plots (70%). The hot water treatment was most effective with pods from the lowest nitrogen plots where the reduction in infection was 50%. (Exploratory)

3. Sweetpotatoes. The death of sweetpotato tissue when immersed in an acetone-insoluble fraction of the juice expressed from Rhizopus-rotted sweetpotato, can be prevented by heating the fraction at 131° F. for 10 minutes. Macerating and toxic activities could not be separated by dilution, by varying the pH from 3.0 to 8.0, or by dialysis of the fraction against distilled water or buffer. This evidence suggests that the toxic principle is protein in nature. Death of the sweetpotato tissue was retarded and maceration was prevented by the addition of 0.5 M KNO<sub>3</sub> to the toxic fraction. (Exploratory)

4. Cantaloups. Immersion of Texas cantaloups for 30 seconds in 135° F. water consistently reduced, and often eliminated, visible mycelial growths on stem scars and rind for 6 days at 60°. Increasing the temperature of the water to either 140 or 145° provided slightly better protection against mold and a marked reduction in bacterial infection of stem scars. Protection against mold and bacterial growths diminished with additional holding over 6 days.

Sodium o-phenylphenate (SOPP) at 0.1 to 0.3% was tested in hot water. Injury, evidenced by browning of sutures and stem scars, resulted with the use of 0.3% SOPP heated to 145° with the 30-second immersion. The results to date do not justify the added expense of including SOPP in the hot water treatment. Treating melons in 135° F. water for 30 seconds increased the pulp temperatures at the 1/4 and 1/2-inch depth 18 and 8.5 degrees, respectively, but the melons cooled to pretreatment temperature (87°) within 15 minutes after treatment. (Exploratory)

A stem-end decay of western cantaloups by Geotrichum candidum was identified on the New York market. Pathogenicity tests indicated the fungus was a weak parasite that developed best in ripened melons at relatively high temperatures. (MQ 2-64)

5. Effects of Chlorine on a Vegetable Decay Organism. Surfactants were found specific in their effect on fungicidal activity of calcium hypochlorite solutions on Alternaria tenuis spores. Certain surfactants increased fungicidal activity at pH 7 and others at pH 8. Depending on the surfactant, raising the surfactant concentration increases or decreases fungicidal activity.

Commercial field washing of mature-green harvested tomatoes in water containing no disinfectants increased the incidence of bacterial soft rot and bacterial necrosis. Holding the field-washed tomatoes at chilling temperatures greatly increased the incidence of both. Commercial field washing and hydro-cooling celery with no disinfectants in the wash or precooler resulted in increased bacterial soft rot. Commercial packinghouse washing of carrots without disinfectants in the water resulted in increased bacterial soft rot. (MQ 2-116)

6. Effects of Ozone on Lettuce and Tomatoes. As little as 0.05 ppm of ozone injured the outer leaves of head lettuce held for 8 days at 36° F. and 90% relative humidity. A cooperative study in commercial tomato ripening rooms showed that ozone at 0.05 ppm had no effect on decay of tomatoes ripened at 65° F. and 80-90% RH. (MQ 2-102)

#### PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

##### Quality Maintenance in Storage

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Kushman, L. J. and F. S. Wright. 1966. Presprouting sweetpotatoes. Supplement to N. C. Agr. Expt. Sta. Hort. Dept. Inf. Leaflet No. 23. (MQ 2-73 and 2-128)

Kushman, L. J. and M. W. Hoover. 1965. Effects of temperatures on acidity of sweetpotato roots and flakes made from them. Amer. Soc. Hort. Sci. Proc. 87:391-397. (MQ 2-73)

Lipton, W. J. and C. M. Harris. 1965. Factors influencing the incidence of translucent scale of stored onion bulbs. *Proc. Amer. Soc. Hort. Sci.* 87:341-354. (MQ 2-56)

#### Quality Maintenance in Transit

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#### Postharvest Disease Control

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Segall, R. H. 1965. Factors affecting fungicidal activity of calcium hypochlorite on spores of *Alternaria tenuis*. *Phytopathology* 55:1075. (MQ 2-116)

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## AREA 13

## INSECT CONTROL IN MARKETING CHANNELS - CROSS COMMODITY

Problem. There are over 100 kinds of insects, 15 or 20 extremely abundant and widespread, that attack agricultural commodities after harvest, in storage, during processing and transportation, and in wholesale and retail marketing distribution. They cause an annual loss of up to one billion dollars through feeding damage or by contamination that reduces quality and value of products. There is need for applied research to develop more effective, economical preventive and control measures that are safe and do not leave objectionable pesticide residues. There is also need for extensive basic research to provide a sound foundation for conducting applied studies, and to provide leads for developing new approaches to prevention and control.

## USDA AND COOPERATIVE PROGRAM

The Department has a continuing program headquartered at Savannah, Georgia, of basic and applied research involving entomology, biochemistry, analytical chemistry, and physics. It is directed toward the solution of problems of insect infestation, damage, and contamination of agricultural commodities and their manufactured or processed products in the marketing channels. The research is conducted in cooperation with the Entomology Research Division, the Commodity Credit Corporation, and the Southern Utilization Research and Development Division; the Armed Forces Pest Control Board; several government agencies, universities, and State Agricultural Experiment Stations; and a number of trade associations or individual firms in the chemical, packaging, paper, synthetic film, food processing, and milling industries. Contributed or transferred funds to assist the program were received from the Department of Defense and the Atomic Energy Commission. Commodities for experimental purposes were made available by the Commodity Credit Corporation, through the Agricultural Stabilization and Conservation Service.

A great deal of the program is conducted extramurally, supported by contract, grant, cooperative agreement, and P.L. 480 funds, distributed in several phases of research as follows:

A. Biological and physical control

A 2-year cooperative agreement with the University of Georgia became effective in June 1966 for research on the effects of light on dermestids and mites that attack stored products.

A 2-year cooperative agreement with the University of Florida became effective in June 1966 for a study on the production and reception of sound by stored-product insects.

A grant was made to the University of Georgia in June 1965 for a 2-year study on the effects of various frequencies and intensities of sound waves on the behavior and physiology of the Indian-meal moth.

A grant was made to the University of Georgia in June 1965 for a 2-year study on the effects of gamma radiation on the physiology and reproductive potential of mites that attack stored products.

A grant was made to Shaw University in June 1966 for a 2½-year study on host specificity in certain stored-product insects.

A grant was made to the University of Georgia in June 1965 for a 2-year study to investigate the existence and origin of a sex attractant pheromone in the Indian-meal moth, and to evaluate the physical and chemical properties of the pheromone.

A 3-year cooperative agreement with the University of Wisconsin became effective in June 1966 for research on a nonpesticidal approach to the control of certain stored-product insects by induced changes in their microbial symbionts.

A grant was made to the Hebrew University, Jerusalem, Israel, for a 3-year study on the potential use of antimetabolites for the control of certain stored-product insects. It continues until August 1968 and involves P.L. 480 funds with a \$65,457 equivalent in Israeli pounds.

A grant was made to the Institute of Plant Protection, Poznan, Poland, for a 5-year study of the insect pathogen, Bacillus thuringiensis, as a possible control measure against certain moths that attack stored products. It continues until May 1967 and involves P.L. 480 funds with a \$17,075 equivalent in Polish zlotys.

A grant was made to the University of California at Berkeley in June 1965 for a 3-year study on the host finding behavior and parasitization performance by a hymenopterous parasite of a moth species that attacks stored products.

#### B. Biology, ecology, physiology, and nutrition

A 2½-year cooperative agreement with the University of Florida became effective in April 1966 for a study on the nutritional requirements of the almond moth.

A 2-year cooperative agreement with the University of Illinois became effective in June 1966 for a study on the utilization of food by certain stored-product insects.

A grant was made to Clemson University in June 1965 for a 2-year study on the bionomics of the Indian-meal moth.

A grant was made to the Iowa State University in June 1965 for a 3-year study on low temperature adaptation and chill coma in stored-product insects.

A 1-year cooperative agreement with the California Department of Agriculture became effective in November 1965 for a study on the identification of Nearctic species of Trogoderma female adults.

A grant was made to the University of California at Riverside in June 1966 for a 3-year study on the comparative life histories and bionomics of Trogoderma species.

#### C. Mode of insecticide action and development of resistance

A grant was made to the Iowa State University in June 1965 for a 3-year study on changes in activities of oxidative detoxication enzymes as related to age and growth stage of stored-product insects.

#### D. Improved pesticidal control

A 2-year contract was awarded to the Vacudyne Corporation in June 1965 for investigations to design, construct, install, and test an experimental fumigation chamber with controlled temperature, relative humidity, vacuum, and pressure features unlike any ever previously built.

#### E. Insect-resistant packaging

A 2½-year contract was awarded to the Battelle Memorial Institute in June 1965 for research to develop practical formulations and methods of application to paper that will prevent migration of insecticides or repellents from packaging components to products inside the containers.

A 2½-year contract was awarded to the Midwest Research Institute in June 1965 for the development of effective insect repellents for protecting stored agricultural commodities and packaged products.

#### F. Simplified pesticide residue analytical methods

A 1½-year contract was awarded to the Midwest Research Institute in June 1965 for research to develop rapid spot test methods for the qualitative detection of the major classes of pesticides in the major food commodities.

A 2-year contract was awarded to the F&M Division of the Hewlett-Packard Company in June 1966 for research to develop a portable gas chromatograph instrument and mobile laboratory for rapid on-site analysis of pesticide residues in plant and animal products.

A 1½-year contract was awarded to the Stanford Research Institute in June 1966 for research to develop simple, rapid methods of extraction and cleanup for pesticide residue analysis.

A 1¾-year contract was awarded to the General Foods Corporation in June 1966 for research on the development of antibody reactions specific for pesticides and their adaptation to rapid and sensitive residue analysis.

The Federal effort on the cross-commodity entomological research in this reporting period totaled 20.9 scientist man-years, of which 3.1 was in contracts, 2.9 in grants, and 0.2 in cooperative agreements. The manpower was divided as follows: biological and physical control, 5.5 plus 1.5 in grants; biology, ecology, physiology, and nutrition, 3.3 plus 0.9 in grants and 0.2 in cooperative agreements; mode of insecticide action and development of resistance, 1.1 plus 0.5 in a grant; improved pesticidal control, 1.3 plus 0.9 in a contract; insect-resistant packaging, 1.4 plus 1.1 in contracts; simplified residue analysis, 1.1 in contracts; and fate and effect of residues, 2.1.

Line Project MQ 1-24(Rev.) on the development of spray treatments for warehouses was discontinued.

P.L. 480 project E21-AMS-1(a), a study in Poland of stored-product mite nutritional requirements was terminated in February 1966, upon completion of the plan of work.

#### PROGRAM OF STATE EXPERIMENT STATIONS

Scientist man-years in this section are included in the 12 commodity areas.

#### REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

##### A. Biological and physical control

1. Light. Electrophysiological studies were conducted in which the retinas of several species of stored-product insects were probed and the response to various wavelengths of light observed on an oscilloscope. The maximum

response in the insects studied to date occurred in the green region of the spectrum. Several species of stored-product insects were exposed to various numbers of flashes of 6943 Å of lased light of 2- and 5-joule intensity. All insects were dead after exposure to the high intensity. (MQ 1-12)

2. Sound. Indications were obtained that the adult red flour beetle might emit a sound with a frequency between 5.5 and 6.0 kilocycles per second when placed under stress. (MQ 1-12)

3. Geotropism. A trap was designed for capturing stored-product insect larvae. The trap takes advantage of the larva's tendency to migrate toward the peaks of piles of peanuts or other commodities. When a trap is placed on one of these peaks, the larvae crawl into the trap and are captured. In tests conducted to date, almond moth, Indian-meal moth, and cadelle larvae and merchant grain and foreign grain beetle adults have been captured. During periods of low temperature, the larval trap was superior to a light trap in capturing almond and Indian-meal moths. (MQ 1-12)

4. Gamma Irradiation. Based on the results of our research, it appears that a radiation exposure of 20 or 25 k-rads will eliminate infestations of the 12 species of stored-product insects thus far investigated. Eggs and larvae are the most sensitive stages, and these are usually killed in a short time or at least prevented from successfully transforming to the next stage. Pupal and adult mortalities are much smaller at these low levels, but adults are normally sterile. Radiosensitivity among the species of beetles appears to be fairly similar. In general, moths appear to be more resistant to radiation than are beetles. (MQ 1-12)

5. Physiological Control. Lack of the vitamins pyridoxine, biotin, folic acid, nicotinic acid, or pantothenic acid in the diet of the hide beetle caused considerable mortality, cannibalism, and growth retardation of the larvae, with complete failure to pupate. Lack of riboflavin had a milder effect, a few larvae pupated but with great delay. Lack of thiamine only prolonged larval growth about 1/3 and reduced longevity of adults about 1/2. Adding different antivitamins to the diet caused varying degrees of mortality, cannibalism, and increased time for larval growth. Against the khapra beetle, the detrimental effect of injections of pyridoxine antagonist increased as the concentration increased, but at all three concentrations tested the number of eggs laid per female was reduced only by 1/3. (A10-MQ-4)

6. Biological Control. Nine biopreparations containing Bacillus thuringiensis were effective against the Mediterranean flour moth as shown by decreases in populations, fertility, and longevity. Three of the preparations, when mixed with flour, showed varying degrees of effectiveness. With

Biotrol only 0.7 percent of the larvae developed into adults. All preparations were more effective against larvae when in loose flour than when in solid, dried paste. (E21-AMS-4)

## B. Biology, ecology, physiology, and nutrition

1. Photoperiod Studies on the Indian-meal Moth. An endogenous circadian rhythm can be brought into Indian-meal moth populations to produce peaks of emergence, mating, and oviposition. By varying the onset of light and dark cycles, it is possible to synchronize populations of emerging adults into daily peaks and also to predict when the highest frequency of mating and oviposition will occur. (MQ 1-56)

2. Metabolism Studies on the Indian-meal Moth. Respiration decreases by 90 percent as the newly molted last instar larva develops to a 1-2-day old pupa, but is subsequently restored to 50 percent in the newly emerged adult. During the last larval instar, when lipid accumulation is most intense, cytoplasmic enzymes responsible for generating reduced nicotinamideadenine dinucleotide phosphate achieve their highest activity. During the same period, alph-glycerophosphate dehydrogenase and aconitase activities decline, while citrate-cleavage enzyme and malic dehydrogenase activities remain unchanged. (MQ 1-53)

Neutral lipids are primarily accumulated during the last larval instar before their utilization in the pupa and adult. Phospholipid content decreases during larval development but is restored during the pupal period. During embryogenesis neutral lipids are extensively catabolized concurrent with an increase in phospholipid content. (MQ 1-53)

3. Insect Rearing. Nineteen species of stored-product insects were reared for use as test insects in the research projects conducted at Savannah, Georgia. The average production was 500,000 insects per week. (Unclassified)

4. Taxonomic Character for Identification of Khapra Beetle Adults. A new morphological character was discovered in adult female khapra beetles that will help provide quicker and more positive identification of this insect, a species that has previously been extremely difficult to identify. The anteromedial metasternal process on adult female khapra beetles is rounded, whereas it proved to be nipple-shaped in specimens of all other species of Trogoderma examined. This finding has been published. About 500 microscope slides have been prepared of dissections from females of four species of Trogoderma, to be used in further work on this project.

(Cooperative Agreement, Calif. Dept. Agr.)

5. Nutritional Requirements of Mites. Proteins (special mixtures), vitamins, mineral salts and other energy sources are required food components for three species of stored-product mites. When albumin was the only protein

available, development was inhibited. Sterols and cholesterol in the egg are sufficient for development through larval and nymphal stages only for some species. Carpoglyphus lactis has very definite food requirements while, in order, they are less for Acarus siro and Tyrophagus infestans. Mite development was inhibited when antimicrobials such as borax, boric acid and hexamethylene tetramine were included in the diet, but materials such as sodium nitrate, diphenyl and sodium pyrosulfite can be used to control microbial contamination in cultures without affecting the mites. Since no symbiotic organisms were found in the bodies of the mites, the influence of antimicrobials and antibiotics is assumed to be directly on metabolic processes. (E21-AMS-1)

#### C. Mode of insecticide action and development of resistance

1. Resistance to Malathion. Six strains of Cadra cautella, two strains of Plodia interpunctella, and two strains of Tribolium castaneum collected from storage or processing facilities were investigated for resistance to malathion. The most resistant strains of these species were 5.8, 16.4, and 2.1 times as resistant, respectively, as the normal laboratory strains. Diazinon and BAY 77488 were investigated for toxicity to malathion-resistant strains of T. castaneum. Although the malathion-resistant strains were also more tolerant of these chemicals than were the standard laboratory insects, they exhibited lower tolerance to BAY 77488 than to malathion, indicating promise for this compound in controlling malathion-resistant insects. (MQ 1-23)

2. Oxidative Detoxication Enzymes. Good progress has been made in this new project in establishing insect cultures and developing methods and procedures. Homogenization and fractionation experiments are now under way to isolate the desired enzymes from different stages of several species of stored-product insects. (MQ 1-43(Gr))

#### D. Improved pesticidal control

1. Preliminary Evaluation. BAY 77488 shows outstanding promise against stored-product insects, with exceptionally high efficacy as a direct-contact, residual, and vapor insecticide. It is of further interest because of its extreme safety, having an LD<sub>50</sub> oral toxicity to rats of 8,000 to 10,000 mg./kg. Followup intermediate evaluation of BAY 77488 will be conducted as soon as the manufacturer releases the material for such testing. Screening tests were conducted with 55 new compounds. Fifteen of these compounds were considered promising and were further tested to determine their direct-contact, residue, or vapor toxicity to the insects. Eight of these promising compounds showed one or more toxic properties and will be used in further developmental studies. (MQ 1-23)

Laboratory tests to evaluate BAY 77488 as a grain protectant showed that this promising new material, applied at 5 p.p.m., killed all adult rice weevils and confused flour beetles exposed to the treated grain. No progeny were produced in the treated grain. (MQ 1-15)

In preliminary laboratory evaluation of candidate fumigants, tetrachloro-cyclopropene and Virginia-Carolina 3-668 showed outstanding promise, among the 26 compounds tested. Both materials were more toxic to test insects than was methyl bromide, used as a standard for comparison. Tetrachloro-cyclopropene penetrated wheat to the same extent as did methyl bromide, but V-C 3-668 appeared not to be a good penetrant. (MQ 1-28)

2. Warehouse Treatment. The dichlorvos space treatment and vapor dispensing unit developed by researchers on this project were tested for an entire season in a subsistence warehouse at the Naval Supply Center, Norfolk, Virginia. The test showed that (1) dichlorvos vapor was effective in preventing insect infestation of packaged foods under practical conditions in a warehouse, (2) the application can be accomplished with one dispensing unit per 100,000 cu. ft. of space, and (3) application at the recommended rate of  $1\frac{1}{2}$  grams of dichlorvos per 1,000 cu. ft. per week resulted in residues of dichlorvos or dichloroacetaldehyde (the degradation product) of less than 1 p.p.m. in the exposed packaged foods during 20 weeks' use. Most of the analyses revealed 0.2 p.p.m. or less, many only a trace or none. (MQ 1-25)

3. Experimental Fumigation Chamber. All technical problems have been resolved, design specifications prepared, and construction should be completed by August 1966. Final steps will be shop-testing, shipment to Savannah, Georgia, installation in the laboratory, and performance testing. (MQ 1-41(C))

#### E. Insect-resistant packaging

1. Evaluation of Repellents. Preliminary evaluation of 57 compounds revealed 17 were more repellent than the synergized pyrethrins standard. Fourteen of these came from a research contract synthesis program at Midwest Research Institute, and 5 of them showed from 80- to 100-percent repellency. (MQ 1-20)

The research contract synthesis program at Midwest Research Institute has produced 46 compounds for evaluation under Line Project MQ 1-20. Nine of 21 carbamates, 2 of 6 maleimides, and 3 of 6 trinitrobenzenes showed greater repellency than did the synergized pyrethrins standard. (MQ 1-40(C))

2. Residue Barriers. Laboratory tests showed that in addition to saran films and coatings, polycarbonate, polyvinyl alcohol, and unplasticized polyvinyl chloride films prevented migration of methoxychlor from a treated sheet into flour. Similar tests showed that polycarbonate, polyvinyl alcohol, and unplasticized polyvinyl chloride films also prevented the migration of piperonyl butoxide as did glassine and saran laminates on polypropylene-covered paperboard. The polypropylene-covered paperboard was less effective. The barrier coatings and formulations prepared under MQ 1-39(C) are also evaluated under this project. Thus far the coating systems containing saran appear to be the most effective ones for preventing migration of piperonyl butoxide or methoxychlor. An additional 38 types of barrier sheets from that contract are under test. (MQ 1-1(Rev.))

Several types of styrene, saran, and ethylene barrier systems have been sent to Savannah, Georgia, and tested for efficacy. Additional types submitted and now under test include polyvinyl alcohol, polyvinyl acetate homopolymers and copolymers, formulations based on zein, and a fluorocarbon material. (MQ 1-39(C))

3. Shipping and Storage Tests. The large-scale shipping and storage test, to compare insect-resistant multiwall paper bags against standard cotton bags in preventing insect infestation of cornmeal while en route from the corn mill in the central U. S. to distribution points in Brazil, was completed. The cornmeal was packed in synergized pyrethrins-treated kraft bags with tape-over-stitch (TOS) or pasted open-mouth (POM) closures and in standard untreated cotton bags with sewn closures. Of 10 bags of each type examined before the ship was loaded at Mobile, Ala., 3 cotton bags were infested while all of the treated kraft bags were insect-free. All meal in cotton bags was fumigated before loading onto the ship. Fifty bags of each type were examined when they were unloaded in Brazil; 56 percent of the cotton bags were infested and only 2 treated kraft bags contained insects. These 2 bags had imperfect closures. Bags of each type at each of two locations were examined after 7 months' storage in Brazil. Less than 20 percent of the 50- and 100-pound kraft bags with TOS closures and of the 50-pound POM bags were infested. More than half of the 100-pound POM bags and 100 percent of the textile bags contained insects. Results of a supplemental test conducted at Savannah with 50 bags of each type correlated well with the results of the shipping test to Brazil. Cornmeal from the treated bags was analyzed for piperonyl butoxide residue. All samples were below the proposed 10 p.p.m. tolerance except one sample from a 50-pound bag. It was only a fraction of a p.p.m. above that level and the average was well within limits. (MQ 1-17)

A large-scale performance evaluation of insect-resistant multiwall paper bags to compare them against standard military packaging is still in progress. The insect-resistant bags had both TOS and POM closures, with heat-sealed adhesives. Eighteen months of warehouse storage under Phase Two of the test showed that 75 percent of the stitch-over-tape (SOT) untreated bags and 50 percent of the treated bags with SOT wax-dipped closures examined were infested, whereas all of the treated bags with TOS or POM closures were insect-free with the exception of the TOS bulk-packed which had 20 percent of the bags infested. The repellent treatment combined with TOS and POM closures provided good protection for 6 months' storage in a heavily infested simulated warehouse at the Savannah laboratory, whereas untreated bags with SOT closures were all heavily infested within 1 month. Piperonyl butoxide in composited samples of flour from treated bags was well below the 10 p.p.m. proposed tolerance. (MQ 1-17)

4. Insect-Resistant Cotton Bags. In studies directed toward developing cotton bags that are insect resistant, a 12-month storage test was conducted with small cotton bags treated with synergized pyrethrum and having overtaped or tapeless seams. Results showed that under conditions of the test good protection was provided by the treatments on bags with or without the overtape. Based on the results of these tests, a large-scale test using 100-pound bags is being conducted. The Southern Utilization Research and Development Division is assisting in this program by developing application methods and by treating the cotton fabric from which experimental bags are constructed. Supplementary laboratory tests showed that waxed kraft paper liners reduced by about one-half the amount of synergized pyrethrum migrating from the treated cloth to the flour. (MQ 1-36)

5. Physical Resistance of Packages to Insect Invasion and Penetration. After 24 months of exposure to insect infestation, small bags of flour made of polycarbonate film that was 2 mils thick or thicker remained free of insect penetrations. Tests with polypropylene-overwrapped cigarette packs have shown this film to be greatly superior to the standard cellophane overwrap in preventing cigarette beetle damage. (MQ 1-22)

A large-scale test involving 60,000 pounds of nonfat dry milk was conducted to investigate the resistance to insect invasion of multiwall bags purchased by ASCS under Type G Specifications. The results showed conclusively that Type G bags provide greater protection against insect infestation than do the Type E bags, and that closure overtapes applied with heat-activated adhesives were superior to tapes applied with water-based adhesives. Repellent-treated bags showed their high degree of effectiveness by keeping all bags insect-free during 6 months of exposure. After 6 months of storage in treated bags, the milk contained less than 2 p.p.m. of piperonyl butoxide. (MQ 1-22)

## F. Simplified pesticide residue analytical methods

The first step in a contract being carried out by the Midwest Research Institute was to survey the types of pesticides from which residues must be considered. They were grouped into 10 classes. The plant and animal products in which residues might be found were then grouped into 11 classes. Then Food and Drug tolerances were reviewed to determine the lowest residue level permitted for each class of pesticide on each class of foodstuff. This information provided a background for establishing the parameters of performance required for simple, rapid analytical methods for pesticide residues in general. The second step was to develop improved techniques for extracting pesticides from plant and animal products and for cleanup in preparation for actual analysis. The third step was to develop simple tests for detecting classes of selected pesticides. This has been done for several of the classes and work is continuing on others. The final contract requirement was to design, construct, and evaluate field pesticide residue analysis equipment for the rapid quantitative detection of pesticides in plant and animal products. A prototype field analysis kit has been constructed by the contractor and is ready for demonstration to the Department and for practical testing. (MQ 1-50(C))

## G. Fate and effects of pesticide residues

1. Chemical Analyses. During the reporting period 3,394 analyses were made to support the entomological research. An additional 927 analyses were made to determine fumigant residues in wheat, flour, and bread in a cooperative study with the Human Nutrition Research Division being conducted to study the effects of fumigation on various nutritional factors. Some time was expended in developing new analytical methods involving infrared spectrophotometry, thin layer chromatography, gas chromatography, and polarography. (MQ 1-29)

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

### Biological and Physical Control

Cogburn, Robert R., Elvin W. Tilton, and Wendell E. Burkholder, 1966.

Gross effects of gamma radiation on the Indian-meal moth and the Angoumois grain moth. Jour. Econ. Ent. 59(3): 682-685. (MQ 1-12)

Kirkpatrick, Robert L., and Phillip K. Harein. 1965. Inhibition of reproduction of Indian-meal moths, Plodia interpunctella, by exposure to amplified sound. Jour. Econ. Ent. 58(5): 920-921. (MQ 1-12)

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Tilton, Elvin W., Wendell E. Burkholder, and Robert R. Cogburn. 1966. Mating competition of gamma-irradiated and nonirradiated male Trogoderma glabrum Herbst. Jour. Econ. Ent. 59(1): 168-169. (MQ 1-12)

#### Biology, Ecology, Physiology, and Nutrition

Boczek, Jan. 1966. Studies on nutritional requirements of selected species of mites of importance to stored products. Dept. of Applied Ent., Warsaw Agr. Univ., Warsaw, Poland. 23 pp., 13 tables. (Final Report on E21-AMS-1)

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#### Improved Pesticidal Control

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Kirkpatrick, Robert L. 1966. Toxicity of seven candidate fumigants to stored-product insect. Jour. Econ. Ent. 59(3): 558-560. (MQ 1-28)

#### Insect-Resistant Packaging

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Laudani, Hamilton, Henry A. Highland, and Edward G. Jay. 1966. Treated bags keep corn meal insect-free during overseas shipment. Amer. Miller and Processor 94(2): 14-19, 33. (MQ 1-17)

### General

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U. S. Dept. Agr., MQRD. 1965. Protecting home-cured meat from insects. Home and Garden Bul. No. 109, 6 pp. November 1965. (MQ-1)

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## AREA 14

## INSTRUMENTATION FOR OBJECTIVE MEASUREMENT OF MARKET QUALITY

Problem. Agricultural commodities vary widely in many of the factors that determine market quality. A continuing need exists for more and better instruments for use in the marketing of agricultural commodities, including instruments to measure color, moisture content, texture, maturity, composition, and to detect defects in a wide range of commodities. Inspection and grading services, food handlers and processors, and research workers in the broad field of agricultural marketing could make use of instruments of this kind. The development of techniques of measurement suitable for use in automatic sorting is included in this area. The rapid conversion to mechanical handling of agricultural commodities makes it imperative that automatic devices be developed to evaluate and control the quality of the product.

## USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving engineers and physicists engaged in the broad field of instrumentation, procedures and methods for use in basic and applied research on market quality of agricultural products. This work supplements other marketing research through superior instrumentation designed for the specific problem under study, and is cooperative with other units of the Division.

The federal scientific effort devoted to research in this area totals 6 scientist man-years.

## PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Scientist man-years in this section are included in the 12 commodity areas.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality1. Electrical Properties.

(a) Corn moisture measurements. A rapid electrical conductance method for determining the variability in moisture content within a sample of corn was developed. The individual corn kernels are pressed between two rotating electrodes (similar to the Tag-Hepenstal Meter) and the current signal (Micro-Amps) is amplified by a logarithmic operational amplifier.

A 10-segment meter relay actuates counters to record the number of kernels within a given moisture content range from 11 to 20 percent. This moisture meter was calibrated by comparing the meter moisture reading with the oven-drying method. FC&AP supplied 54 samples of 200 kernels each (10,800 kernels) with moisture content ranging from 11 to 21 percent as determined by the oven method. The data from these 10,800 kernels were automatically recorded on punch tape and analyzed on the Mathatron Computer. The correlation coefficient was 0.98 with standard deviation of moisture content of 0.5%.

## 2. Light-Transmittance Techniques.

(a) Apples. An extensive study was conducted with Red Delicious apples to determine the optimum wavelengths for light-transmittance measurement of apple quality. The absorption spectrum of more than 1,000 intact apples was recorded at harvest time and after 5 months' storage. The wavelength range from 510 to 850 nm was recorded for each sample with the absorbance readings at every 10-nm interval punched on paper tape. Taste panel scores, soluble solids, and titratable acidity were determined upon removal from storage and this information was also punched on paper tape. The data are now being processed to determine the optimum transmittance measurement for each of the quality factors.

(b) Moisture measurement of soybeans. Previous work had shown that light-transmittance measurements in the near-infrared region could be used to measure the moisture content of ground grain. This work has been repeated with improved equipment and for soybean samples having a greater range in moisture content. The calibration curve for ground soybeans relating moisture content to  $\Delta O D$  ( $1.94 - 2.08\mu$ ) is linear up to 4 percent moisture. Above this level, scatter effects introduce non-linearity. A standard error of  $\pm 0.1$  percent was obtained comparing the light-transmittance method to standard oven method for samples ranging from 0 to 18 percent moisture. Drying conditions did not show any adverse effect on the measurement. Drying and rewetting of samples did not cause deviations from the calibration curve. Samples heated to produce obvious browning also showed no deviations. Therefore, the light-transmittance technique provides a rapid, accurate, reliable method for measuring the moisture content of soybeans.

(c) Moisture measurement of potatoes. Preliminary work on the measurement of moisture content of potato slices indicates promise. The absorption difference,  $\Delta O D$  (865 - 815 nm), was found to be inversely correlated with moisture content for potato slices having 70 to 80 percent moisture.

The large standard error of  $\pm 1.0$  percent was caused by variations in the light-scattering properties of the samples. The light-scattering properties are also a function of moisture content, and a study of the light scattering indicates the possibility of a more precise moisture determination by measuring both absorption and scattering power. This will be studied further.

(d) Fat content of milk. Measurements of the near-infrared absorption characteristics of whole milk indicated a relationship between the fat content and scatter intensification of the water absorption bands. The  $0.97\text{-}\mu$  band was chosen as most suitable for analysis and the absorption difference between  $0.97\mu$  and  $0.90\mu$  was correlated with fat content of whole milk samples having a range of from 2.7 to 5.4 percent in fat content and from 1.029 to 1.033 in specific gravity. The correlation coefficient between  $\Delta O D (0.97 - 0.90\mu)$  and fat content was 0.86. Correcting for specific gravity improved the correlation to 0.94 and gave a standard error of  $\pm 0.25$  percent fat. This is the standard error to be expected in the Babcock test used in this study. These studies indicate that a rapid, non-destructive measurement of the fat content of milk is possible by light transmittance.

3. Sonic Resonance Techniques. Nametre Company of Edison, New Jersey, performed tests under contract to evaluate acoustic or sonic techniques for measuring textural properties of fruits and vegetables. Even though the majority of measurements were made on apples, an acoustic spectra has been successfully recorded for bananas, oranges, and tomatoes. Results on apples showed that it is possible to vibrate and resonate whole intact fruits and cylindrical sections of tissue taken from the fruit. Natural variability among apples and within an apple can be conveniently and accurately measured in terms of its modulus of elasticity and internal friction. The square of the resonance frequency of the whole apple multiplied by its mass has been designated by the contractor as an "acoustic maturity constant." It appears more likely, however, that this parameter will be more promising as a non-destructive measure of firmness within agricultural commodities.

(MQ 3-72(C))

Sonic resonant techniques were used to determine the dynamic elastic modulus and internal friction of apples, bananas, carrots, peaches, pears, sweet potatoes, and white potatoes. Sound energy radiated from a horn-type speaker driver was transmitted through air to cylindrical specimens of tissue suspended by two cotton threads. The frequency range from 100 to 10,000 cycles per second was scanned and the amplitude of vibration was recorded. The use of modulus of elasticity as a definitive, objective, rapid measure of firmness within agricultural commodities is being proposed. The higher the elastic modulus, the firmer the product; a decreasing elastic modulus indicates softening of the commodity. Representative values for elastic modulus, designated in lb. per in<sup>2</sup>, for fully matured commodities are: carrots, 3910; sweet potatoes, 1900; Irish Cobbler potatoes, 1800; Red Delicious apples, 975; Red Haven peaches, 430; and Valery bananas, 150. Further evaluation of these techniques as related to textural measurement is planned.

#### 4. New Instruments.

(a) Automatic data handling. Two general-purpose systems have been assembled for digital recording of data from research instruments. One system uses a voltage-to-frequency converter and an electronic counter to drive a high-speed paper tape punch. This system has a maximum speed of thirty

characters per second and has been used with a recording spectrophotometer to provide digital recording of absorption vs. wavelength information. The second system uses a standard eight-line teletype to record the output from a digital voltmeter. This system provides a printed page as well as a punched tape output. Programming for output format is performed by paper tape fed into a tape reader which is part of the teletype. The maximum speed of this system is eight characters per second, but it is very flexible and has been used on a number of instruments. It is also used for keyboard entry for punching of paper tapes.

The punched tape from both of these systems can be processed directly by the Mathatron desk calculator. This complete data-handling system provides rapid processing of research data with a minimum of labor.

## B. Biophysics.

1. Photoperiodism in insects. Work with the Entomology Research Division on photoperiodism is continuing. Simple low-cost spectrographs have been built to expose insects to light of controlled intensity, wavelength distribution, and time period. These spectrographs provide an intensity of up to 50  $\mu$  watts/cm<sup>2</sup> over the 450 to 800 nm wavelength range. Minimum spectral bandwidth is 25 nm, and an irradiated area of 30 cm<sup>2</sup> is available for each waveband. Three such units have been constructed and experiments begun with the codling moth larvae (Carpocapsa pomonella) and giant silkworm pupae (Philosama cynthia pryeri).

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

### Objective Measurement and Evaluation of Quality

Birth, Gerald S., and Karl H. Norris. 1965. The difference meter for measuring the interior quality of foods and pigments in biological tissue. USDA Technical Bulletin 1341.

Massie, David R., and Karl H. Norris. 1965. The spectral reflectance and transmittance properties of grain in the visible and near infrared. Transactions of the American Society of Agricultural Engineers, 8 (4): 598-600.

Norris, Karl H. 1965. Measuring and using light transmittance properties of plant materials. Electromagnetic Radiation in Agriculture (Conference Proceedings, October 1965, pp. 64, 65 and 66), Published jointly by Illuminating Engineering Society, New York, N. Y., and American Society of Agricultural Engineers, St. Joseph, Mich.

Biophysics

Butler, W. L., and W. R. Briggs. 1966. The relation between structure and pigments during the first stages of proplastid greening. *Biochim. Biophys. Acta*, 112: 45-53.

## PUBLICATIONS -- STATE EXPERIMENT STATIONS AND COOPERATIVE PROGRAMS

Objective Measurement and Evaluation of Quality.

Black, B. C., and Hammond, E. G. 1965. Separation by dielectric distribution: application to the isolation and purification of soybean phosphatides and bacterial spores. *J. Am. Oil Chemists' Soc.* 42 (11), pp. 936-939. (Iowa)

Deck, R. E., Thompson, J. A., and Chang, S. S. 1965. A multiple trap carousel micro fraction collector for gas chromatography. *J. Gas Chromatography*, 3 (11), pp. 392-393. (N. J.)

Francis, F. J. 1965. Watermelon color measurement with the Agtron. *Proc. Am. Soc. Hort. Sci.* 86, pp. 617-620. (Mass.)

French, Dexter, et al. 1965. Separation of starch oligosaccharides by high temperature paper chromatography. *J. Chrom.* 19, pp. 445-447. (Iowa)

## AREA 15

## PIONEERING RESEARCH - MARKET QUALITY

Problem. Fresh fruits and vegetables are still living organisms after harvest and continue many vital processes that involve biochemical and physiological changes and activities. Rate of ripening, aging and susceptibility to disease are factors greatly influencing the storage and marketing life and the quality of fruits and vegetables. Since fundamental processes in the plant tissues in a large measure govern these changes a continuing need exists for more basic information on postharvest physiology, including enzymatic activities, the biosynthesis and function of various natural occurring volatiles, reactions of mitochondria including the electron transport chain, the cytochromes, and other factors associated with respiration and its regulation. This information should furnish a basis for a better understanding of the fundamental behavior of agricultural commodities, and result in improved quality in the products that reach the consumer.

## USDA PROGRAM

The Department has a continuing program at Beltsville, Maryland, involving plant physiologists and chemists engaged in basic studies directed toward developing information on the physiological and biochemical changes that occur in fruits and vegetables and other plant material after harvest under conditions that may be encountered in transportation, storage and marketing. This work supplements and is cooperative with other marketing research in the Division.

The Federal scientific effort devoted to research in this area totals 3 scientists' man-years.

## REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Postharvest Physiology

1. Structure and Purity of Mitochondria. A cooperative study with the Departments of Zoology, Botany, and Plant Biochemistry, University of California at Los Angeles, has given training and experience in electron microscopy to one member of the Pioneering Laboratory. This cooperative study has also established the following concepts of ultrastructure in plant mitochondria. Mitochondria considered intact by the biochemical criterion of respiratory control show numerous cristae which are swollen

and spherical in media containing 0.4M sucrose but are contracted and elongate in 0.25M sucrose. When the cristae are swollen, the matrix is highly condensed but as the cristae contract the matrix expands to occupy the space made available by the shrinking cristae. Serial sections used in studying compartmentation allowed an interpretation of volume changes. A method involving sucrose density-gradient centrifugation was developed for purifying plant mitochondria. By using this procedure mitochondria can be prepared that are essentially free of plastids, starch and other cellular debris yet retain their respiratory capacity and ultrastructure.

2. Ethylene. The discovery that methionine or linolenic acid can give rise to ethylene in vitro in a cuprous catalyzed model system (Multiple Use Report 1965) has led to further attempts to relate these substances to ethylene formation and aging in fruit and other plant cells. It was found that methionine incorporated into apple and tomato tissues serves as a substrate for ethylene. This finding establishes one of the possible origins of ethylene in plant metabolism. Although linolenate is present in the lipid fraction in plant tissues, attempts to incorporate it into tissues without injury have not been successful. A number of autoxidizable products of linolenic acid have been tentatively identified and some of these products are powerful in vitro precursors of ethylene. Future studies will attempt to establish the identity and pertinence of these products to ethylene formation in vivo. Data now available indicate that the autoxidation of unsaturated fatty acids may have a definite relationship to the aging process in metabolism. Natural antioxidants such as  $\alpha$ -tocopherol (Vitamin E) may protect these unsaturated acids from autoxidation. The Vitamin E content of apple fruit during its entire life cycle is being studied. Cooperative studies with Dr. P. Hochstein, Duke University, have shown that rat liver microsomes produce lipid peroxides which in the presence of the cuprous catalyzed system forms ethylene. Other cooperative studies with Dr. G. Cohen, College of Physicians and Surgeons, Columbia University, are assessing the role of Vitamin E deficiency in animal systems in relation to lipid peroxidation and ethylene production.

3. Electron Transport. The phenomenon of reversed electron transport first recognized by B. Chance, University of Pennsylvania, may be a major source of energy coupling that is lost in aging tissues. However, very little reversed electron transfer was found in a number of plant storage tissues. A very sensitive spectrofluorimeter, built by K. Norris, Instrumentation Research Laboratory, is now being used to measure reversed electron transfer in intact tissue slices.

## PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Postharvest Physiology.

- Lieberman, M., A. T. Kunishi, L. Mapson, and D. A. Wardale. 1965.  
Ethylene Production from Methionine. *Biochem. J.* 97: 449-459.
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Methionine. *Plant Physiol.* 41: 376-382.
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Microsomes. *Science* 152: 213-214.
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and Avocado. (Abstract). *Proc. Annual Meetings, Am. Soc. Plant  
Physiologists.* p XXV.
- Spalding, D. H., and M. Lieberman. 1965. Factors Affecting Production  
of Ethylene by P. digitatum. *Plant Physiol.* 40: 645-648.

## Line Project Check List -- Reporting Period July 1, 1965 to June 30, 1966

Work & Line Project Number	Work and Line Project Titles	Line Proj. Summary of Progress	Incl. in Area and Subheading
MQ 2	:Maintaining and improving agricultural product quality in storage, transportation, and handling		
	: Program Leadership		
MQ 2-7(R)	:Control of deterioration of rough rice	:Hyattsville, Md.	
MQ 2-29	:Detection and description of freezing injury	:College Sta., Tex.	Yes :4a-B-1
MQ 2-33	:Packaging Eastern peaches and nectarines*	:Beltsville, Md.	Yes :12-C-3
(R)			No :
MQ 2-42	:Loading methods and protective services for Maine potatoes*		No :
MQ 2-45	:Modified atmospheres for berries*		No :
MQ 2-52	:Gray mold of peppers*		No :
MQ 2-53	:Precooling and transporting Florida citrus fruits and vegetables*	:Orlando, Fla.	Yes :1-D-1
MQ 2-55	:Transit temperatures - California potatoes	:Fresno, Calif.	Yes :9-D-1
MQ 2-60	:Host-parasite physiology of market diseases*		No :
MQ 2-61	:Antioxidants, metabolic inhibitors on vegetables*	:Beltsville, Md.	Yes :12-B-2
MQ 2-62	:Deterioration of grass seed	:Beltsville, Md.	Yes :4b-B-1
MQ 2-63	:Plastic film for Eastern fruit	:Beltsville, Md.	Yes :3-B-1
			:3-C-1
MQ 2-64	:New market diseases	:Belle Mead, N.J.	Yes :12-F-4
MQ 2-65	:Post-harvest diseases Florida citrus	:Orlando, Fla.	Yes :1-B-1
			:1-F-1
MQ 2-66	:Control of pear scald*		No :
(C)			:
MQ 2-67	:Forecasting storage diseases of apples		No :
MQ 2-69	:Storage temperatures and processing quality of potatoes	:E. Grand Forks, Minn.	Yes :9-C-1
MQ 2-70	:Deterioration of grain in storage	:Beltsville, Md.	Yes :4-B-2
MQ 2-71	:High nitrogen or carbon dioxide in shipments of fruits and vegetables	:Beltsville, Md.	Yes :12-D-1,3
		:Harlingen, Tex.	:
MQ 2-72	:Lenticel spot of Golden Delicious apples*		No :
MQ 2-73	:Reducing injury, decay and shrinkage of sweet potatoes*		No :
			:
MQ 2-74	:Florida grapefruit on European markets	:Orlando, Fla.	Yes :1-D-2
MQ 2-75	:Maintaining meat quality	:Beltsville, Md.	Yes :5-B-1
			:10-B-1
MQ 2-76	:Cause and prevention of heat damage in rough rice	:College Sta.,Tex.	Yes :4a-B-2
MQ 2-77	:Cause and prevention of damage and off color in rough rice*	:College Sta.,Tex.	Yes :4a-B-3
			:
MQ 2-78	:Bruising of potatoes during handling into storage		No :
MQ 2-79	:Respiration and rind breakdown in citrus fruit*		No :
MQ 2-80	:Prepackaged vegetables	:Belle Mead, N.J.	Yes :12-B-1
MQ 2-81	:Quality retention of eviscerated poultry		No :
MQ 2-82	:Gamma radiation and market life of fruits and vegetables*		No :
			:
MQ 2-83	:Transit environments on Western strawberries	:Fresno, Calif.	Yes :3-D-1
			:3-F-4
MQ 2-84	:Fruits and vegetables in mechanically refrigerated cars and trailers	:Fresno, Calif.	Yes :9-D-2
			:12-D-1,2
MQ 2-86	:Chilling injury of eggplant		No :
MQ 2-88	:Ripening of Florida grown tomatoes		No :
MQ 2-89	:Storage of asparagus crowns		No :
MQ 2-90	:Effects of heat treatments on potato diseases	:Presque Isle, Me.	Yes :9-E-1
MQ 2-91	:Apple and pear scald	:Beltsville, Md.	Yes :3-E-1
		:Wenatchee, Wash.	:
MQ 2-92	:Ventilation rates and humidity of potatoes	:Presque Isle, Me.	Yes :9-C-2
		:Beltsville, Md.	:
MQ 2-93	:Prestorage and handling of Maine potatoes	:Presque Isle, Me.	Yes :9-B-1
MQ 2-94	:Composition and maturity of blueberries	:Raleigh, N.C.	Yes :3-B-2
MQ 2-95	:Decay of onions in storage	:Belle Mead, N.J.	Yes :12-F-1
MQ 2-96	:Radiation and pathogenicity of fungi	:Chicago, Ill.	Yes :3-F-9
MQ 2-97	:Proteolytic enzymes in relation to market decay	:Belle Mead, N.J.	Yes :1-F-5
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## Line Project Check List -- Reporting Period July 1, 1965 to June 30, 1966

Work & Line Project Number :	Work and Line Project Titles :	Work Locations :	During Past Year :	Line Proj. Incl. in Summary :	Area and Subheading :
MQ 1 :	Methods for the prevention and control of insects : : attacking agricultural products in the marketing : : channels Program Leadership :	Hyattsville, Md. :			
MQ 1-1(R) :	Packaging insecticide formulation studies :	Savannah, Ga. :	Yes :		13-E-2
MQ 1-6 :	Fumigation studies on cheese mites* :		No :		
MQ 1-7(R) :	Ecology of stored-tobacco insects :	Richmond, Va. :	Yes :		11-A-2
MQ 1-9 :	Infrared rice dryers for insect control :	Fresno, Calif. :	Yes :		4a-C-1
MQ 1-12 :	Physical energy for detecting and controlling insects :	Savannah, Ga. :	Yes :		6-C-1
MQ 1-15 :	Laboratory evaluation of protectants for commodities :	Tifton, Ga. :			13-A-1,2,3,4
		Fresno, Calif. :	Yes :		3-G-1
		Manhattan, Kansas :			4-C-1
		Savannah, Ga. :			13-D-1
MQ 1-16 :	Forced-distribution fumigation of grain in commercial storages :	Manhattan, Kansas :	Yes :		4-C-3
MQ 1-17 :	Storage tests of insect-resistant packages :	Savannah, Ga. :	Yes :		13-E-3
MQ 1-18 :	Effects of air movement on stored-grain insects* :		No :		
MQ 1-19 :	Protective treatments for rough rice :		No :		
MQ 1-20 :	Preliminary evaluations of compounds for insect resistant packages :	Savannah, Ga. :	Yes :		13-E-1
MQ 1-21 :	Preliminary storage tests of insect resistant package treatments :		No :		
MQ 1-22 :	Physical resistance of packages to insects :	Fresno, Calif. :	Yes :		3-G-1
		Savannah, Ga. :	Yes :		13-E-5
MQ 1-23 :	Preliminary evaluation of insecticides :	Savannah, Ga. :	Yes :		13-C-1
					13-D-1
MQ 1-24 :	Development of aerosol and mist spray formulations* :		No :		
MQ 1-25 :	Spray application studies for warehouses :	Savannah, Ga. :	Yes :		13-D-2
MQ 1-26 :	Laboratory evaluation of moth-proofing compounds :	Savannah, Ga. :	Yes :		8-B-1
MQ 1-27 :	Intermediate evaluation of grain protectants (R) :	Fresno, Calif. :	Yes :		3-G-1
		Manhattan, Kansas :			4-C-3
		Tifton, Ga. :			6-C-1,2
MQ 1-28 :	Laboratory evaluation of fumigants for stored-product insects :	Savannah, Ga. :	Yes :		13-D-1
MQ 1-29 :	Determination of chemical residues :	Savannah, Ga. :	Yes :		13-G-1
MQ 1-31 :	Preconditioning stored-product insects to fumigants* :		No :		
MQ 1-32 :	Studies of natural attractants in dermestids (C) :	Fresno, Calif. :	Yes :		2-B-1
MQ 1-33 :	Effects of fumigant residues on quality of tobacco* :		No :		
MQ 1-34 :	Controlling insects in and around fruit processing plants :	Fresno, Calif. :	Yes :		3-G-1
MQ 1-35 :	Toxic and repellant materials for cigarette beetles :	Richmond, Va. :	Yes :		11-A-3
MQ 1-36 :	Development of insect-resistant cotton bags :	Savannah, Ga. :	Yes :		13-E-4
MQ 1-37 :	Flowing steam under vacuum to control tobacco insects :	Richmond, Va. :	Yes :		11-A-1
MQ 1-38 :	Effects on insects of dockage in wheat** :		No :		
MQ 1-39 :	Protection of packaged food against pesticides (C) :	Savannah, Ga. :	Yes :		13-E-2
MQ 1-40 :	Insect repellents for food packages and grain (C) :	Savannah, Ga. :	Yes :		13-E-1
MQ 1-41 :	A fumigation and controlled environment chamber (C) :	Savannah, Ga. :	Yes :		13-D-3
MQ 1-42 :	Host finding and parasitization performance by a hymenopterous parasite (GR) :		No :		
MQ 1-43 :	Oxidative detoxication enzymes of stored-product insects (GR) :	Savannah, Ga. :	Yes :		13-C-2
MQ 1-44 :	The bionomics of the Indian-meal moth (GR) :		No :		

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Work & Line Project Number	Work and Line Project Titles	Work Locations	During Past Year	Line Proj. Summary Progress	Incl. in Area and Subheading
MQ 3	:Basic research on quality evaluation and development of objective measurements of quality factors in agricultural products				
	: Program Leadership	:Hyattsville, Md.			
MQ 3-3(C)	:Quality indicators for stored wheat*	:Beltsville, Md.	: Yes		:4-A-1
MQ 3-16 (R)	:Determining the degree of milling of rice*		: No		
MQ 3-17	:Relation of cotton fiber properties to yarn strength*		: No		
MQ 3-21 (CR)	:Mechanization of seed purity analysis	:Beltsville, Md.	: Yes		:4b-A-1
MQ 3-24	:Equipment for sampling and grading small grains and oilseeds*	:Beltsville, Md.	: Yes		:6-A-3
MQ 3-25	:Oil quality changes in long term storage	:Washington, D.C.	: Yes		:6-B-7
MQ 3-27	:Quality measurements of red tart cherries*	:Beltsville, Md.	: Yes		:3-A-3
MQ 3-28	:Quality measurements of apples*	:Beltsville, Md.	: Yes		:3-A-1,2
		:Wenatchee, Wash.			
MQ 3-29	:Methods and equipment for grading farmers' stock peanuts	:Raleigh, N.C.	: Yes		:6-A-1
MQ 3-30	:Lighting system for grain inspection*		: No		
MQ 3-31	:Assessing the sanitary quality of commercial egg solids*		: No		
MQ 3-32	:Seed metabolism	:Beltsville, Md.	: Yes		:4b-A-2
MQ 3-33 (C)	:Production, harvesting, and ginning practices on cotton quality	:Clemson, S.C.	: Yes		:7-A-1
MQ 3-34	:Evaluating market quality of livestock and meat	:Beltsville, Md.	: Yes		:5-A-3
MQ 3-36	:Measurement of flour yielding capacity of wheat	:Beltsville, Md.	: Yes		:4-A-3
MQ 3-38	:Maturity determinations in Italian prunes*		: No		
MQ 3-39	:Physical techniques for determining purity of grass seeds	:College Sta., Tex.	: Yes		:4b-A-3
MQ 3-40	:Determining susceptibility of potatoes to bruising:		: No		
MQ 3-41	:Rapid method for determining moisture of hay	:College Sta.,Tex.	: Yes		:4b-A-4
MQ 3-42	:Surface contamination of cotton fibers	:Clemson, S.C.	: Yes		:7-A-2
MQ 3-43	:Measuring the frictional properties of cotton fibers	:Clemson, S.C.	: Yes		:7-A-3
MQ 3-44 (C)	:A study of methods for grading milk*		: No		
MQ 3-45	:Rapid measurement of refining loss in cottonseed oil	:Washington, D.C.	: Yes		:7-B-1
MQ 3-46	:Aromatic polynuclear hydrocarbons in or on citrus fruit	:Pomona, Calif.	: Yes		:1-A-2
MQ 3-47	:Evaluation of cotton fiber testing instruments	:Clemson, S.C.	: Yes		:7-A-4
MQ 3-48	:Automatic alternating temperature seed germinator	:College Sta.,Tex.	: Yes		:4b-A-5
MQ 3-49	:Predicting keeping quality of anhydrous butter fat	:Beltsville, Md.	: Yes		:2-A-1
MQ 3-50	:Fresh product factors to processed quality in sweetpotatoes	:Beltsville, Md.	: Yes		:12-A-1
MQ 3-51	:Reevaluation of official cottonseed standards	:Washington, D.C.	: Yes		:7-B-2
MQ 3-52	:Lighting for grading and inspection of poultry	:Beltsville, Md.	: Yes		:10-A-2
MQ 3-53	:Seasonal changes in Florida Persian limes	:Miami, Fla.	: Yes		:1-A-3
MQ 3-54	:Techniques for handling grass seeds for analysis	:College Sta.,Tex.	: Yes		:4b-A-6
MQ 3-55	:Physiological and biochemical factors in seedling vigor	:Beltsville, Md.	: Yes		:4b-A-7
MQ 3-56	:Raw product factors and processed quality in potatoes		: No		
MQ 3-57	:Microstructure and keeping quality of butter	:Beltsville, Md.	: Yes		:2-A-2
MQ 3-58	:Measuring protein content of grain sorghum	:Beltsville, Md.	: Yes		:4-A-4
MQ 3-59	:Lighting requirements for evaluating meat quality	:Beltsville, Md.	: Yes		:5-B-2
MQ 3-60	:Marbling and palatability of beef	:Beltsville, Md.	: Yes		:5-A-1
MQ 3-61	:Flavor and palatability of beef		: No		
MQ 3-62	:Standards for maturity evaluation of beef	:Beltsville, Md.	: Yes		:5-A-2
MQ 3-64	:Verification of varietal designation of crop seed	:Beltsville, Md.	: Yes		:4b-A-8
	:Continued next page				

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: *Discontinued during reporting period
:**Initiated during reporting period
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